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The Mayor and the Wires.

MAYOR GRANT seems to have entered with renewed activity into his annual campaign against the electric light companies. While his heart has apparently been softened toward electric traction, it seems, perhaps, not so much the suppression as the transference of venom; and His Honor evidently intends to make it pleasant for the high tension electric lighting companies to the very best of his unfortunately great ability. Meanwhile the objects of his solicitude are bringing suit for half a million or so as the result of damages sustained through the former favors that he has accorded them. Very charmingly juvenile is His Honor's frame of mind. There are numerous bad boys who would far rather expend their energies in tying a tin can to a dog's tail then in doing, even casually, any useful work, and the Mayor's present divertissements strongly suggest that, in spite of his apparently mature years and long connection with practical politics, his mind is still young and frisky.

Properties of Ring Magnets.

SOME very instructive experiments by Prof. A. E. Dolbear are reported in another column. They deal with the effect of strains in the iron on the properties of a closed magnetic circuit. Some very striking results were obtained, showing that even the periodic changes in shape due to elasticity of form, such as sound vibrations for instance, set up similar waves in the magnetic field. These facts have an interesting bearing on some of the subjects with which we have to deal in telephonic work, but Prof. Dolbear, who is constantly seeking after the molecular conditions in magnetism and electricity, indulges in some very pretty and ingenious speculations as to the possibility of conditions similar to those he has investigated occurring in molecular ring magnets. This is an intensely interesting field of research, and while at present there is no immediate promise of practical results, it is to such investigations that we must look for further light on the extraordinary phenomena that indirectly accompany change of magnetic and electrical state in the intimate particles of any material body.

Material for Resistance Coils.

A BRIEF paper, given elsewhere in our columns, shows the results of careful tests of a variety of alloys recommended for use in resistance coils. Three things are essential in the material to be used for this purpose: its resistance should remain constant, it should have a high specific resistance to lessen the size of the coils and simplify winding them, and it should have a very low temperature coefficient. Pure metals fulfill the first condition well, the second fairly well, and the third indifferently. There are easily obtained alloys that have both a high specific resistance and a low temperature coefficient, but the permanence of the resistance is generally somewhat doubtful. Platinum and platinum silver alloy are usually regarded as the most satisfactory in respect to uniformity of specific resistance aside from the changes produced by temperature. German silver is probably the substance most often used. Drs. Feussner and St. Lindeck find that this material changes in resistance under various conditions, almost always increasing slightly. Even winding the wire produces a slight increase in its resistance, and exposure to an unusually high temperature produces a change from which there is never complete recovery. Several other materials were tried with virtually the same result. The best qualities as regards permanence were obtained from an alloy of 75 per cent. copper and 25 per cent. nickel. This possessed a specific resistance about that of ordinary German silver, but a lower temperature coefficient. The most extraordinary effects were noticed in alloys of nickel, manganese and copper. Two such alloys were tried, and one of them showed even a negative coefficient. The moral of the experiments is that alloys of a high specific resistance are likely to show serious irregularities; they seem to be far more susceptible to permanent change from variations of temperature and mechanical operations than pure metals, and are consequently less reliable. Resistance boxes should be made standard at a determined temperature, and the temperature coefficient plainly marked on them. In very many cases of commercial testing no account need be taken of it; but inasmuch as an error of five per cent. or more may be produced by neglecting the change in resistance due to temperature, it behooves the electrician to keep an eye on his resistance coils, at least far enough to note whether he is likely to introduce a serious error in the tests at hand.

Very High-Speed Railroading.

WE publish this week the extremely interesting paper read by Mr. O. T. Crosby before the American Institute of Electrical Engineers. These experiments conducted by Mr. Crosby at Laurel, Md., attracted much attention about a year ago, but the results of them are only now laid before the public. His task was a difficult one, for the light track was totally unsuited for the enormous speeds employed, and the construction of the motor car itself was not adapted to secure the best results. The experiments must be conceded to have been of the greatest interest and usefulness, as they demonstrated beyond a reasonable doubt the power of the electric motor to develop speeds that had heretofore existed only in imagination. Under the circumstances, the rate of 120 miles per hour, which was attained, is little short of marvelous, and it is safe to predict that, with a reasonably good track, instead of an intolerably bad one, this could have been increased nearly 50 per cent. The air resistances that have been so much feared by those who have considered very high-speed traction were shown in these experiments to be not at all so formidable as had been imagined, and, as Mr. Crosby plainly states, it is evident that the limit of the speed that can be reached by motors is determined more by the track than by anything inherent in the apparatus. With a solid roadbed and a track carefully laid with rigid and heavy rails, there is not the slightest reason to doubt the practicability of speeds as high as 150 miles per hour. It is sometimes said that nobody would care to ride at such a rate; but the same statement was made not so very many years ago regarding the enormously dangerous and altogether reprehensible speed of 25 or 30 miles an hour. It was then, as now, a question of track more than anything else. With the locomotive there is a practical speed limit set by the permissible size of boiler and the amount of fuel that can be carried. In the case of the electric motor, however, there is no difficulty on the score of supplying power. The only limitation is in the weight efficiency of the motor itself; and it is impossible to predict what this might be. It would certainly only be reached at a speed higher than has ever yet been seriously contemplated. Electrical high-speed traction is in the air to-day, and probably within a very few years we shall be treated to a practical demonstration of its advantages on a large scale. Its commercial success is presumably somewhat dependent on the radical nature of the improvement secured, and an electric railway between this city and Chicago, that would reduce the running time from 24 to 18 hours, would have no special reason to expect remarkable returns. If, however, it should make the trip in eight or ten hours, it would infallibly attract a very large patronage. Mr. Crosby's balance sheet is certainly encouraging from a commercial point of view, and it should be remembered that it is one of the very few estimates that have been based on a careful study of the necessary expenses. Too many similar computations have been (some of them deliberately) made to depend on estimates derived from the most uneconomical street car practice with inefficient and unnecessarily costly motors. The time has now come when papers like the one before us deserve to be read, not only by the electrician but by the practical railroad man and the financier.

Alternating Currents of Short Period.

ELSEWHERE in our columns will be found two brief and pertinent papers by Prof. Elihu Thomson on some experiments with alternating currents of very high frequency. They follow directly upon Mr. Tesla's discussion of the same subject in THE ELECTRICAL WORLD of Feb. 21. Prof. Thomson's work was done with a machine having 100 armature coils, constructed on the plan recently devised by him, wherein no wire moves and the only revolving part of the machine is a mass of laminated iron having poles projecting radially outward. The highest number of alternations obtained from this apparatus was about 8,000 per second, and, therefore, far lower than the enormous frequencies reached by Mr. Tesla. The phenomena observed by the two experimenters were naturally similar: the higher frequency giving the more striking and remarkable results, as might have been anticipated. The most interesting addition to our knowledge, however, is to be found in the brief report by Prof. Thomson of Dr. Tatum's experiments on the physiological effects of very rapid alternations. Prof. Thomson placed his alternator at the disposal of Dr. Tatum, and the latter continued the experiments which have been several times reported in our columns on the action of high-tension currents upon animal life. His results have rendered it highly probable that the fatality of the alternating current varies nearly inversely with its frequency. At 4,500 alternations per second the current required to kill dogs was 20 times the strongest current survived at 120 alternations per second. The same difference in effect, though in a less degree, was observed when the alternations were raised even to 300 per second. The cause of this really extraordinary state of affairs cannot be assigned in the present state of our knowledge of the subject. Certain experiments make it appear probable that it is physiological rather than produced by any difference of current distribution in the case of the higher frequencies. This latter point, however, cannot be regarded as entirely settled until further experiments are tried, because of our very limited information as to the distribution of current through the body in any case. The deduction to be drawn from the results is that rapid alternations are probably less dangerous to human life than slower ones. It is likely that the well-known deadly effects of open-circuit direct-current arc light machines may be due to the decidedly violent fluctuations of the current at a rather low frequency. Color is lent to this hypothesis by the behavior of closed-coil arc machines. In one case recently reported a contact through the two hands across mains having a difference of potential of 3,100 volts did not produce any very serious results. There is, therefore, strong evidence now in hand that the undoubted danger that attends the use of high-tension alternating currents could be somewhat reduced by the simple and very valuable expedient of increasing the frequency. Danger aside, with very high frequencies it becomes possible to obtain the transformation of very large amounts of electrical energy in converters of diminutive size. It is also practicable to use the condenser form of converter without the need of very large capacity, and the principal convenience sacrificed is the ability to use single wires of large diameter. For currents of very high frequency, stranded wires or flat strips become absolutely necessary in order to avoid loss from anti-effective copper. Another possible disadvantage would be the effect of the violent static displacement currents, that are produced at very high frequencies, on the insulation of the wires. Elaborate experiments covering these two points, the largest permissible size of wire and durability of insulation, would possess great commercial value. And if frequencies of 500, and perhaps even 1,000, per second can be successfully employed the usefulness of the alternating current will be very considerably increased. Probably the practical limit of frequency would be determined, however, by the highest number of alternations at which motors can be successfully operated. Beyond a certain point of frequency the alternating motor is not likely to work successfully for magnetic reasons. This limit is, however, certainly far above the frequency that is to-day generally employed. It is altogether probable that there will be a decided gain in employing a periodicity five or possibly even ten times that of our present commercial alternators. At all events the subject is one that should be most carefully investigated from a practical standpoint.

Latest Foreign Electrical News.

(By Cable from our Regular Correspondent.)

London, March 9, 1891.—Mr. Ferranti's report for 1890 to the shareholders of the London Electrical Supply Corporation states that within three months the central station at Deptford will be in a position to supply 90,000 lights, with complete arrangements for parallel working. The two great 200,000-light machines will probably be ready next year, but at first will only work at about half their full output.

The Central London Railway bill is now being considered before a select committee of the House of Commons. Up to the present its promotors have been successful, in spite of the most strenuous efforts made to show that the scheme will prove unremunerative and is the result of Yankee speculation.

In the Kensington-Paddington Subway Railway scheme the cable system has been substituted for electric traction, not on account of any distrust in the latter, but by reason of violent objections raised in behalf of the City and Guilds of London Technical College. The proposed route passes necessarily directly under the laboratories of that institution, and while the vibrations would seriously interfere with scientific work, the enormously powerful and constantly varying current that would be employed would render anything like exact research almost out of the question.

The decline of the telephone monopoly was made manifest last week by the Mutual Telephone Company opening its first exchange in Manchester.

NEW BOOK.

Practical Electrical Engineering, by W. W. Beaumont, M.I.C.E.; C. H. W. Biggs, M.I.E.E.; C. Capito, M.I.E.E.; G. Kapp, M.I.E.E.; A. Reckenzaun, M.I.E.E.; P. Sellon, M.I.E.E.; J. Swinburne, M.I.E.E.; H. Swan, M.I.E.E. Parts I., II., III., and X. Biggs & Co., London. 1890. Price 75 cents per part.

This book purports to be a complete treatise on the construction and management of electrical apparatus as used in electric lighting and the electric transmission of power. A number of clever electrical engineers contribute the various sections, and the whole treatise, when complete, will consist of two large quarto volumes. Parts I., II. and III. begin the work, while Part X. is the first section of the second volume, the intermediate parts having not yet appeared.

The purpose of the treatise is to gather information concerning that part of practical electricity that deals with the arrangement and use of apparatus for electric lighting and the transmission of power. After explaining the ordinary facts about electricity, the apparatus of the station is taken up in detail, considering the prime movers, and then, afterward, the various electrical apparatus that is required. The first section of the work deals with general electrical principles, the properties of conductors and electrical circuits, Ohm's law and its applications, and similar rudimentary facts concerning electricity. A little later, in Chapter III., the magnetic circuit is discussed, and then the fundamental facts of electrical induction. Part II. also has a somewhat useful chapter on graphical construction, and finally the central station itself is taken up, beginning with the engineering details of the foundation. Part III. deals with steam boilers in a rather complete way. Taken together, these three first parts of Volume I. produce on the reader a somewhat favorable impression. The illustrations are very numerous and excellent, though the publisher has seen fit to displace them in a most inexcusable fashion. There is no conceivable use or interest in having a fine plate of electroliers inserted, apropos of nothing whatever in a discussion of Ohm's law, nor is there any pertinence in thrusting working drawings of a motor into a chapter that gives no account of the machine illustrated.

Like every book produced by the collaboration of a number of authors, the present work shows a very noticeable lack of unity, although the separate sections are useful and valuable. Part X., being the first of Volume II., is by Gisbert Kapp, and deals with dynamos, alternators and transformers. Mr. Kapp, as usual, jumps into the middle of his subject and treats it vigorously and effectively. His chapter on magnetism and the properties of electromagnetic induction are most admirable, and contain an efficient summary of the facts as known up to date. Part X. terminates abruptly in the middle of a chapter on induced electromotive force. It is unfortunate that, for commercial reasons, the publishers should have been led into the mistake of producing in disjointed sections a work which might be so important. To judge from the examples before us the completed will be a most useful one, a treatise that will be found convenient by nearly every electrical engineer. At the same time it is singularly lacking in unity and system of treatment, as might have been anticipated from the number of authors. It will probably also be somewhat uneven in merit, and should be regarded not so much as a practical treatise on electrical engineering as a series of valuable and interesting monographs on that part of practical electricity that has to do with the production and distribution of electrical energy. It is well worth procuring as a book for reference in dealing with engineering problems, and contains an amount of practical, even if somewhat heterogenous, information hard to equal in any book on the subject that has as yet appeared.

An Experiment with the Electric Arc.

BY WM. STANLEY, JR.

Prof. Thomson's paper on arc lights calls to my mind an experiment in the laboratory some time ago with an alternate current arc, which presented a very beautiful illustration of the deflecting power of a strong magnetic field. Inside a hollow carbon tube about two inches in diameter was placed an ordinary seven-eighths inch carbon, separated from the tube by about one-quarter of an inch air space all around except where it was held in place by an insulating ring, as shown in Fig. 1. A coil of wire connected in

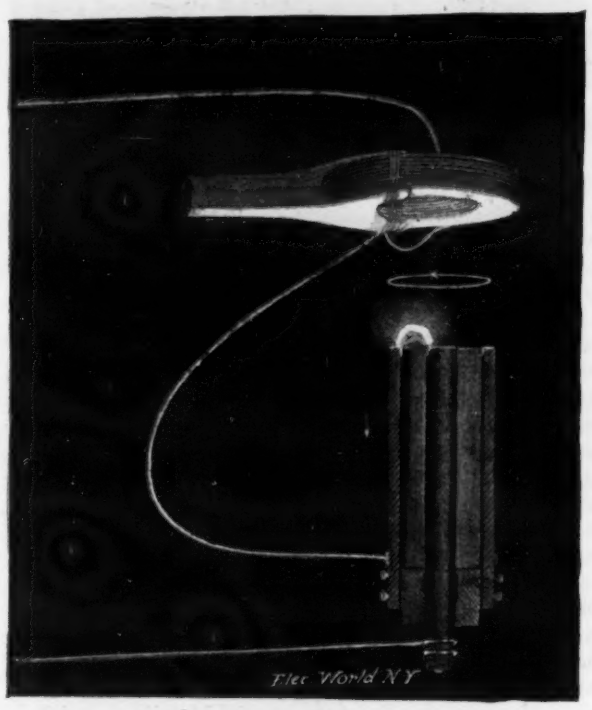


Fig. 1.—Rotation of the Electric Arc.

series with the carbons, and with a constant current transformer by a flexible cord, was mounted to a handle for convenient handling.

If an arc was started between the inner carbon and the concentric tube, and if the coil was approached parallel to the face of the carbons, the arc revolved around the centre carbon after the manner of a pin-wheel. Reversing the face of the coil—that is, the direction of the field threading the arc—caused an instantaneous reversal in the direction of rotation of the arc.

When the coil was placed around the concentric carbons and near the arc, the latter became distorted, as shown in Fig. 2, while it continued to revolve about the axis of the coil.

Many modifications will suggest themselves to any one attempting the experiments. One point observed by Prof.

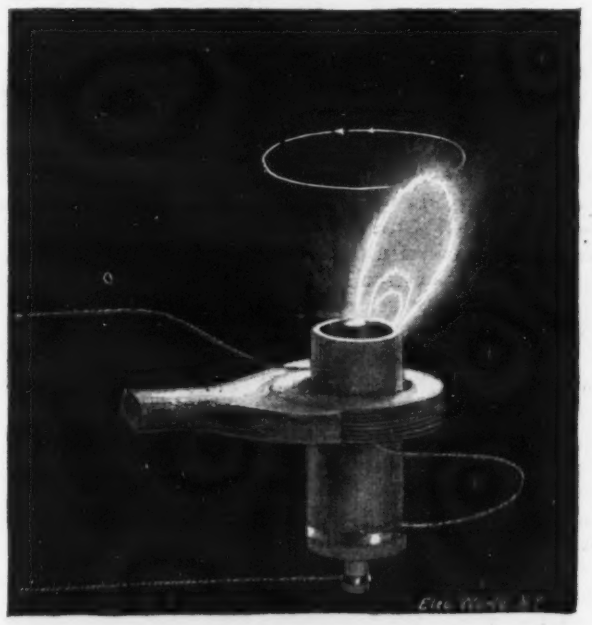


Fig. 2.—Simultaneous Repulsion and Rotation of the Arc.

Thomson was very clearly evidenced, which was that when the arc was whirling (and it might be made to whirl so rapidly as to appear continuous about the centre carbon) the potential required to maintain a constant current rose enormously, so high, in fact, that the transformer was often unable to supply the demand for increased potential necessary to maintain the arc, although it was constructed to deliver a constant current from short circuit to 800 volts; as a consequence, the whirling arc would repeatedly blow itself out with a loud report if the deflecting coil was approached very near the seat of the arc. Of course, the arc revolves and becomes distorted because of the reactions between the field produced by the coil and the weaker field about the arc, and an apparent continuous effort exists between the two fields to coincide or join together. Many beautiful lecture and demonstration experiments for classes may be obtained from this same simple apparatus, which, of course, may be operated with equal success by either alternate or direct currents.

Notes on Alternating Currents of Very High Frequency.

BY ELIHU THOMSON.

The interesting account of his novel experiments given by Mr. Nikola Tesla in The Electrical World of Feb. 21, 1891, relating to the phenomena of alternating currents of very high frequency, leads me to make a statement of some of my own observations while working in similar directions. The highest number of alternations which I have had at my disposal up to the present is 8,000 per second, a rate somewhat below that which Mr. Tesla has obtained, but which, nevertheless, shows properties and brings about actions and results similar to those which he describes. The physiological actions of these rapidly alternating currents have been very ably investigated by Dr. Edward Tatum, some of the results of whose work I have presented in a separate communication. Mr. Tesla's experiences in relation to the static effects of these currents of high frequency are similar to those noted by myself, particularly the small surface of the condenser, which is able to transfer, or permit to be transferred, a considerable amount of energy through a dielectric, owing to the exceedingly high rate at which the changes of direction of charge are made.

The following experiment, which was tried by me some months ago, is interesting in this connection: An incandescent lamp bulb was constructed in which only a single platinum leading-in wire was used, on the end of which, inside the bulb, was mounted a single slip of carbon of two or three inches in length, it being one leg of a broken incandescent lamp filament. Two-thirds of the lamp bulb was now immersed in an outer vessel of water, leaving the single wire above the water for attachment to the source of alternating currents at one terminal, and the other terminal was connected with the outside water, which was rendered slightly conducting by salt dissolved therein. The water surrounding the lamp bulb formed, of course, an outer condenser coating, while the vacuous space and straight slip of carbon were the means for the conveyance of a charge to and from the inside surface of the bulb, which was, of course, exhausted to the ordinary vacuous condition, as found in an incandescent lamp. When an alternating potential of about 1,000 volts, and with a rate of alternations up to 5,000 per second, was applied to the carbon strip, the filament was brought to bright incandescence simply by the bombarding action of the residual gas, as in the Crookes tubes, while of course no complete circuit existed, but only the condenser action of the lamp bulb, allowing sufficient current to flow. At the same time the glass of the lamp bulb not immersed in the water became rapidly heated, indicating that that portion which was immersed in the water would have become equally heated had it not been subjected to the cooling action of the water itself.

The retention of the arc, as with direct currents, and the high note evolved by it have been noted from the beginning of my experiments with these high-period currents. Mr. Tesla expresses surprise that he was enabled to hear the note from an arc in which the alternations of current were more than 10,000 per second. Mr. Tesla will pardon me for calling his attention to the fact that he is taking as the limit of audition in this case sounds of from 5,000 to 10,000 complete waves per second, which is far below the limit at which sounds become inaudible to ordinary ears, cases existing in which a pitch corresponding to over 30,000 per second has been heard, according to some authorities.

The cause of the persistence of the arc with very high-period alternations, as stated by Mr. Tesla, is undoubtedly the correct one, *i. e.*, that the gas stream has no time to cool between the alternations, and its variations of temperature must therefore be quite slight. The conductivity of the vapor or gas stream constituting the arc therefore remains nearly constant when the rapidity of alternations is sufficiently great.

The characteristics stated by Mr. Tesla as requisite to be possessed by machines suitable for obtaining constant current for the working of arc lights are, of course, connected with the fact that in such machines the characteristic curve indicates a drop or fall in the electromotive force developed on a slight excess of current above the normal, and on a decrease of current arising of the electromotive force to a point above the normal. It is not, however, in accordance with my experience that the undulation of the current is almost essential to the success of an arc-light system; nor do I think that properly constructed clutch lamps depend for their success, any more than do finely constructed clockwork lamps, on the presence of a rapidly varying current due to a small number of armature coils and correspondingly small number of segments in the commutator. In fact, I have run with perfect success clutch lamps in circuit with coils of such large self-induction that any but very slight fluctuations were wiped out and without introducing any particular difference in the behavior of the lamps. It probably is true, however, that slight gentle fluctuations occurring at very moderate intervals may be of benefit in the working of clutch lamps by keeping the clutch mechanism in a state of vibration or tendency to open or close; but it can scarcely be doubted that if this benefit exists for such lamps a similar benefit would exist on the operation of clockwork lamps, as a similar fluctuation would give rise to a continual tendency in such lamps to

keep the detent or escapement free enough for delicately letting go teeth for the feed; but the fact that large numbers of lamps are in use in which the feeding of the carbon either by clutch or by clockwork is under the control of a derived circuit magnet only, and that such lamps operate with the greatest satisfaction, shows that the undulations mentioned by Mr. Tesla are not necessarily a factor to be considered. In such cases the self-induction of the arc branch is negligible as compared with that of the derived circuit magnet controlling mechanism, and the fluctuations, therefore, would pass through the arc without affecting the said magnet to a perceptible degree, particularly as the potential around the mound arc with slightly different current strengths flowing is nearly constant. I may add that the experiments of Mr. Tesla in relation to the action of the condenser and the elevation of potential brought about by it are decidedly interesting, and point to the possibility of obtaining a pure resonance effect. This would require, however, that the periodicity of the alternations be preserved very rigidly during the experiments, and involves the production of an unvarying or perfectly constant speed in driving the generating machine, a condition not easily obtained in practice.

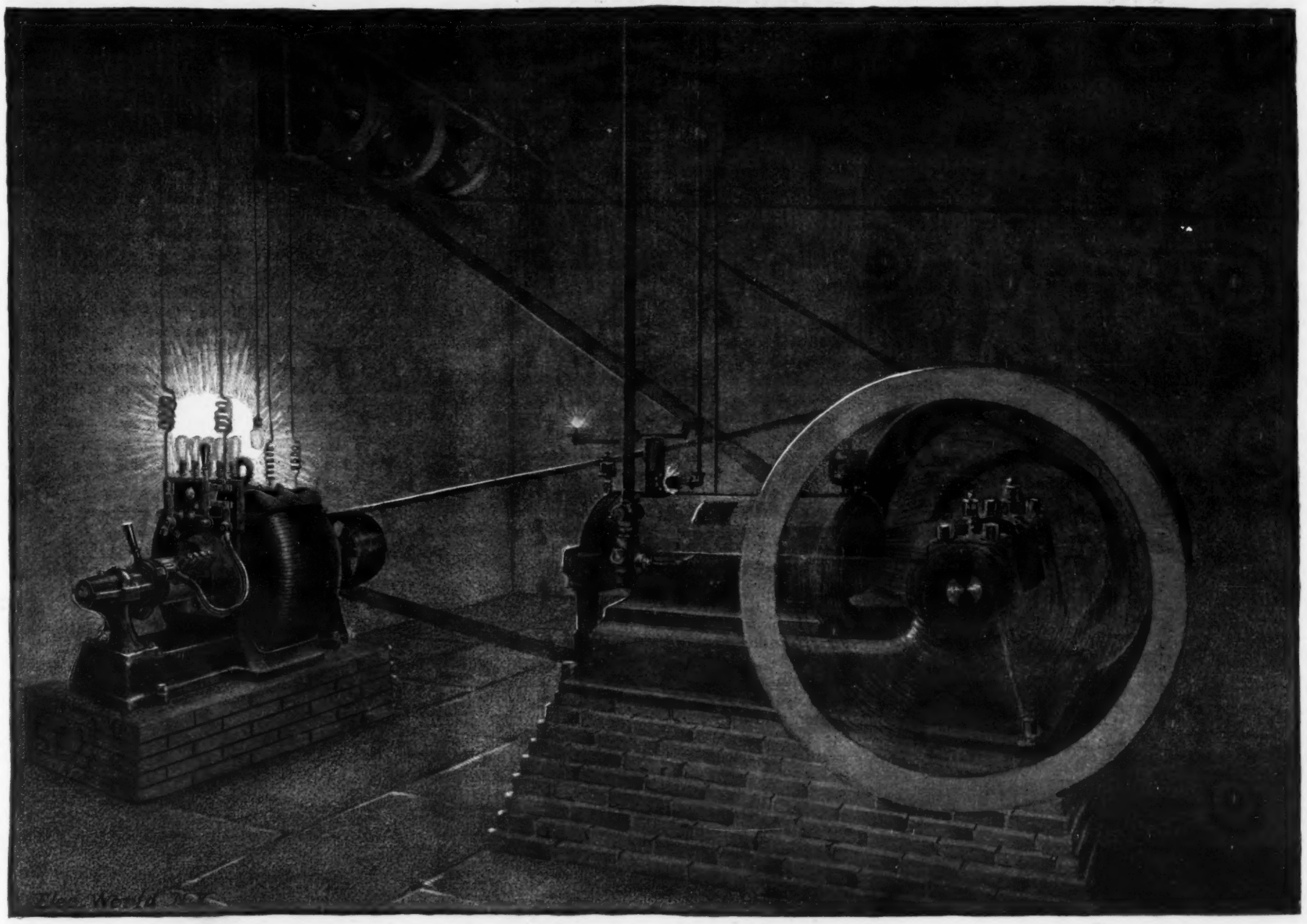
In making the above notes on the highly interesting and valuable account given by Mr. Tesla, I desire to state that, in whatever way my notes may appear as criticism of Mr. Tesla's views, they are not made in any unfriendly spirit, but with the desire of reaching the exact facts which it is the object of scientific investigation and discussion to ascertain.

Metallic Thermometer with Electric Recording Gear.

M. Chibout, says *Le Génie Civil*, has brought out a very sensitive metallic thermometer, constructed so that readings can be taken at a distance. It consists of a transmitter, or thermometer proper, and an electrical receiver. The transmitter consists of a bar of metal which easily expands, such as zinc in thin plates, but of such a section that it possesses the greatest rigidity possible. This bar is fixed at one end to a marble support, and at the other is joined to the short arm of a lever; to the long arm of the same lever, and at the side of it, is fixed another similar bar, and the other extremity of the second bar acts on a similar lever, to the long arm of which is fixed a rack-gearing with a small pinion, on the axis of which is carried a pointer working over a dial, which registers in degrees the movement caused by the expansion of the two bars. Each joint between an expansion rod and a lever is made by means of a piece of spring steel, so as to avoid friction and still allow perfect play. Upon the last lever is fixed a radial contact-maker, which moves over a sector consisting of contact pieces insulated from each other. The receiver consists of a solenoid, in the centre of which is a spindle carrying a pointer traveling over a circular dial. The pointer carries at one end a small piece of soft iron, which, in the normal state, rests against another stationary piece of soft iron Under the influence of the current which proceeds from the distant apparatus, the two pieces of soft iron become magnetized with the same polarity and repel one another, and the needle travels through an angle proportional to the intensity of the magnetizing current, so that a record is given on the receiver similar to that on the thermometer dial itself. The instrument is specially intended for allowing the temperature of distant rooms, where a constant heat must be maintained, to be read in the office.

An Isolated Electric Light Plant Operated by a Gas Engine.

The accompanying illustration is a view of the isolated incandescent light plant in the factory of the Weser Piano Company, on Forty-third street, in this city. The dynamo is a standard type "C. & C." machine of 175 lights, which is driven by a 15 h. p. White & Middleton gas engine. A two-ton elevator in the same building is also driven by the same gas engine. The lights are run every day from about 4 P. M. to 10:30 P. M., and the average load during the working hours of the factory is nearly the full capacity of the dynamo.



A PRIVATE ELECTRIC LIGHT PLANT OPERATED BY A GAS ENGINE.

The White & Middleton gas engine is a new type of machine which has only been upon the New York market since last August, and the cost of operating the entire plant with this engine has been as low as $30 a month. With such low running expenses and high efficiency this rather unique plant will rival the larger station of the same kind illustrated in THE ELECTRICAL WORLD last July.

Mr. Emery's Lecture at the Electrical Society.

On Friday evening of last week the members of the New York Electrical Society met in Prof. Chandler's lecture room at Columbia College to listen to an address by Mr. Charles E. Emery on "The Utilization of the Forces of Nature." The address was accompanied by a large number of lantern views shown upon the screen in illustration of the various forces of nature. Mr. Emery very briefly reviewed in an interesting manner the various ways in which the engineer has contrived to take advantage of nature's forces to accomplish useful and difficult work.

The Construction and Care of Electric Railroads: I. The Bonding of the Track.

BY ARTHUR E. COLGATE.

In the successful operation of all single trolley electric railroads it is necessary to provide suitable means for maintaining a complete metallic circuit, which is generally accomplished by connecting one pole of the generator (in most cases the positive one) to the rail or supplementary return wire, the other pole being connected to the trolley wire.

Many attempts have been made to operate roads on what is known as a grounded circuit; that is to say, by using the earth for the return circuit. This practice, although advocated by some—one man even going so far as to apply for patents on the details of this form of construction—is, in the writer's opinion, poor policy, except as a makeshift. In case of necessity it may be done by driving bars into the soil in the vicinity of the tracks, to which the rails are connected by wires, or by connecting the rails to the remains of some defunct tin roof, which should be buried in the moist earth.

The wire leading from the dynamo should be connected to a similar ground plate, which ought to be about 20 feet square. This was done in the case of the Essex Electric Road in Peabody, Mass., and has proved quite successful. I understand that this method of grounding is to be done away with on this road and bonding substituted at an early date.

One of the first methods of connecting the rails was to drive copper wedges between their ends, but this did not give satisfaction, owing to the expansion and contraction of the rails. The method which came into use was that of connecting each rail to the rail next it by means of a copper or iron bond, which should be of sufficient sectional area to carry the current with almost no loss, No. 6 copper wire being the size in general use. At every fifth rail the two sides of the track should be united by means of a No. 0 copper wire, and in the case of a double-track road both tracks should be connected at about every tenth rail by a similar bond. The object of cross-connecting the tracks and rails is to insure a continuous circuit should any of the bonds become broken by the settling of the pavement or of the rails.

In case of the track being of the ordinary stringer type and already laid it is best drilled by means of an upright drill clamped to the rail and operated by hand. The drill I have in mind is very strong and light and when operated by two ordinary laborers it will bore a ⅞-inch hole in ⅝-inch iron in about four minutes, including the time taken to

set it in position. The best mode of operating is to raise the end of the rail and insert under it a block of wood about 12 × 3 × 3 inches to keep it in place. On no account should the men be allowed to use stones for this purpose, as they are liable to slip out at the most inopportune moments, and the spring of the rail is quite sufficient to amputate a finger or two with surprising quickness. After the end of the rail is secured in position the drill is fastened to the rail by means of a clamp and set screw. I may say here that a spanner should always be used in connection with this rail, as a monkey wrench soon becomes so clogged with sand as to render it useless. A hole is then drilled through the thinnest part of the rail about three inches from the fish plate.

The driller then proceeds to drill all the rails in rotation. At every fifth joint he drills a hole two feet from the fish plate for the reception of the long bonds. A corresponding hole is also drilled in the opposite rail. At

Fig. 1.

every tenth rail, if it be a double track road, an extra hole is drilled in the inside rail for the other cross bond. I consider it the wiser plan to have enough drillers to enable them to keep quite a distance in advance of the rest of the gang, for various reasons, the most prominent one being that the drills suffer less from being clogged with dirt.

After being drilled the holes should be countersunk to the depth of about one-eighth of an inch by means of a countersink and carpenter's brace. One of the best tools for this purpose is made like that shown in Fig. 1. Such countersinks can be made by any blacksmith, and are easily sharpened. It is necessary to keep them very sharp, as they are absolutely useless if dull.

After the holes are countersunk the paving between rails at the joints is removed for the space of about two feet, and an excavation made just wide enough to enable a man to dig out the soil to a sufficient depth to expose the ties. The men engaged in this work labor to the best advantage in sets of three, two loosening the paving, while the third removes it. At the extra holes for the cross bonds a small trench should be dug, uniting them.

On the completion of the digging the bonds are riveted in place. This should be done by men working in pairs, one man raising the rails, while the other does the riveting. The end of the rail is raised by means of a bar, and a block of iron is placed under it parallel with the stringer. This block should be about 8 × 1½ × 3 inches. The end of the rivet is then riveted in the hole, and is forced home by allowing the rail to spring down on it. Sometimes it is necessary to pound on the rail with the head of the bar, which will help very materially in forcing the rivet into place. The riveter must exercise care and see that his helper does not cut the wire off between the web of the rail and the riveting plate. While the plate is still in this position the projecting end of the rivet is cut off flush with the rail, and a head formed which fills up the countersinking. The end of the rail is then raised again, the block removed and the stringer cut away sufficently to allow one-half inch clearance between it and the head of the rivet, which gives the rail a chance for free movement without danger of severing the bond between the stringer and the web of the rail.

The rivet in the other end of the bond is fastened to the adjoining rail in the same manner. After this the bond is

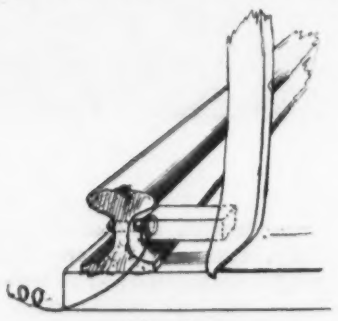


Fig. 5.

bent down alongside the stringer, held in place by a *tinned* iron staple, and the paving replaced. The cross bonds should be buried deep enough to be out of danger of being broken by the settling of the pavement. All bonds should be of sufficient length to allow a slight movement of the rail caused by expansion, loose spikes, the passing of cars and other vehicles. The writer prefers those bonds which are made of one piece of copper, as they are not so liable to cause trouble by the rivet becoming loosened from the side. There is another excellent bond made by having a hole in the rivet near the head just large enough to contain the wire, which is then upset in such a manner as to cause it to jam, making it impossible for it to pull out. (See Fig. 2.) If the bonds are made by twisting the wire around the rivet under the head and then soldering it, it is good policy to examine them and see that the rivets do not taper near the head under the wire; also make sure that the wire is up close to the head of the rivet. If they do not comply with these requirements they should be rejected as worthless, for they will cause endless trouble by the wire breaking loose. The rivets should be about one-fourth of an inch longer than the thickness of the rail for which they are intended, the projecting end being cut off as has been described, and should be one thirty-second of an inch larger than the holes in the rail.

Figs. 3 and 4 show about the correct shape of the rivet. Attaching bond wires to the track by a hole drilled partly through the rail, into which the wire is inserted and held in place by a dowel pin, has rather fallen into disrepute owing to the wire breaking off close to the rail when the paving is replaced. But there is no reason why this arrangement should not be used on suburban roads where there is no paving and the road is not used for a highway, though care should be taken not to cut the wire when inserting the pin.

All methods of bonding without the use of a supplementary return wire are generally avoided for various reasons, the most prominent one being that the breaking of a number of bonds caused by the removal of rails will produce trouble. But in this case a short length of wire might be run temporarily to take the place of the rails which have been taken up during repairs.

Frogs, switches and other castings should be connected in the same manner as other rails, but should be wired by a small gang of men after the rails are all done.

These castings should be drilled from the top down, though much difficulty in drilling is sometimes experienced owing to the presence of sand and slag. The latter usually is found low down, and is so hard that it will turn the edge of the hardest drill. The best way to drill these difficult castings is to use a Morse twist drill which has been tempered glass hard, which should be turned and fed very slowly, being kept moist with turpentine, to which a little spirits of camphor has been added. After drilling all but one-fourth of an inch take out the drill and put in a punch, which

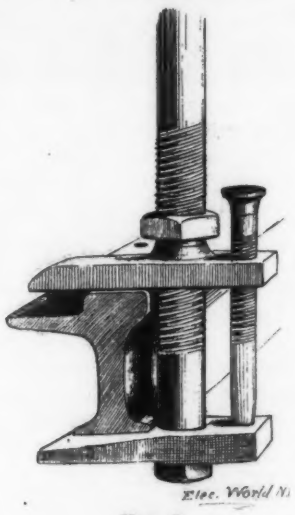


Fig. 6.

may be struck with a sledge. This treatment will cause the lower coating of slag to give way. Care must be taken not to strike hard enough to fracture the casting. In crossing steam and other railroad tracks their rails at the point of crossing should also be connected with the track or, better, with the return wire.

The most approved manner of bonding track is by means of a return supplementary wire, which should be one No. 0, or two of No. 3, tinned copper. After the rails are drilled and countersunk in the manner just described, the paving should be removed at the joints in the left hand side of the track between the rails. These openings are deepened enough to expose the ties, or very nearly to that depth. A ditch is then dug next to the right hand stringer on the inside of the track, to a sufficient depth to enable the supplementary wire to be easily stapled to the ties. The bonds are now riveted in place, every alternate bond on the left hand side being long enough to reach across the intervening space to the ditch opposite, where it is afterward connected to the supplementary wire; adjoining left hand bonds are connected, and the joint soldered. The right hand bonds should be about six inches longer than the height of the stringer, which will allow two wraps around the supplementary wire, two bonds being fastened in each rail. After the bonds are riveted in place the supplementary wire is run out along the ditch. This wire should be No. 0 tinned copper (and should be purchased in coils not larger than about 150 pounds each), to which the bonds are connected by wrapping the ends around the wire. Gas tongs are far better than pliers for this work, on account of the latter getting clogged with sand. The joints are now all soldered by pouring hot solder into them, holding a ladle underneath to catch the surplus. The solder must be very hot for this work. A large charcoal furnace is about the best means of keeping it at the proper temperature. All gasoline apparatus the writer has ever seen proved a failure on account of getting clogged with dirt. After the joints are soldered the wire is fastened down in place by means of tinned staples, one being driven into every third tie.

In bonding track while being laid the holes are drilled and the rivets fastened in before the rails are finally in place. A small hand punch may be advantageously used for this purpose.

After the rails are placed in position and the ties tamped two No. 8 wires are run out to the stringers and the ends of the bonds fastened to them. These two wires are connected every 200 feet by means of short pieces of wire of the same size. The object in using two wires in this case is a saving of copper in the bonds, which is quite an item in a long road.

Girder and T rails should be drilled through the side, but in the case of rails already laid this is not practicable except in the latter case, where a ratchet drill may be used. The rivets are held in place while being headed by means of a crowbar and block of iron about 6 × 6 × 3 inches, and is used as shown in Fig. 5.

In bonding Johnstown rails already in use the drill is clamped to the rail as is shown in Fig. 6, the soil having previously been dug away to a sufficient depth to allow the drill to be easily set in position. To rivet bonds in this type of rail it is necessary to use a bar with a flat

Fig. 2.

Fig. 3.

Fig. 4.

turned-up end, similar to a claw bar such as is used for the purpose of drawing spikes. This is used in connection with the riveting block as is shown in Fig. 7. One man holds the rivet in place while the head is being formed by the other.

The rivets of broken bonds should be removed with a punch to which a wooden handle is attached. Extra long bonds may be made by twisting the wire around the rivet close up to the head and there securing it by soldering. Tinned rivets are the best for this purpose, but if it is impossible to procure them already tinned this may be done by heating them red hot, plunging them into a saturated solution of sal ammoniac to which a little muriatic acid has been added and then dipping them while still wet into melted solder. The workman should take great care during this process, as the solder is almost sure to spatter.

Castings through which it is impossible to drill may be connected to the rest of the circuit by placing a copper plate under them which is connected to the suplementary wire, and spiking them down with extra long spikes, or by bolts, to insure good contact. Girder rails are sometimes grounded in a similar manner by means of a sheet of copper between the rail and chair.

Discharge Rate of the Reynier Storage Cell.

BY HARRY E. DEY.

In a communication in the last issue of The Electrical World by Dr. I. Kitsie, he makes the statement that "the Reynier cell, with its normal discharge rate of three to six ampères, would be a dismal failure." The doctor appears to forget that ampères are not the only requirement for running a car. Those "deadly volts" enter largely into consideration. The above cell having, as it does, an E. M. F. of 32 volts, means a discharge rate of 100 to 200 watts, or ⅛ to ¼ h. p. A 200 ampère-hour cell of the usual type,

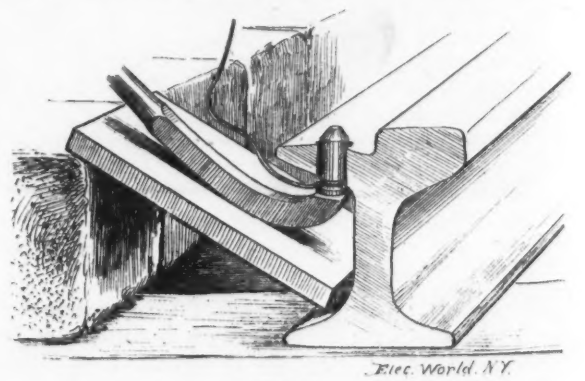


Fig. 7.

with a normal rate of 40 ampères at two volts, is equal to 80 watts, or about $\frac{1}{10}$ h. p. With an equal number of cells (coupled, if desired, in multiple series), I fail to see where the failure comes in, unless it is on the other side.

The Smoking of a Ceiling above Incandescent Lamps.

BY MINOR M. DAVIS.

Mr. A. B. Upham, in The Electrical World of March 7, attributes the "smoking" of ceilings above incandescent lamps to the dust carried by air currents maintained by the heat of the lamps. If a pipe carrying steam be placed under the ceiling of a room, dust will accumulate much more rapidly just above the pipe than elsewhere on the ceiling. This is not a discoloration due to the heat from the steam, but a deposit readily removed by brushing. The "smoking" above an incandescent lamp is probably due to the same cause as that above a steam pipe, and Mr. Upham has, in the opinion of the writer, given the true explanation.

Report of High-Speed Electric Railway Work.*

BY O. T. CROSBY.

The experiments here reported were the first serious efforts ever made to at once double railway speeds, and as such should, I think, be systematically recorded. They were made for the Electro-Automatic Railroad Company of Baltimore, Md. This company was organized about four years ago by Mr. David G. Weems, who, though not an engineer, was convinced that the electric motor would give very high speeds for the transportation of parcels.

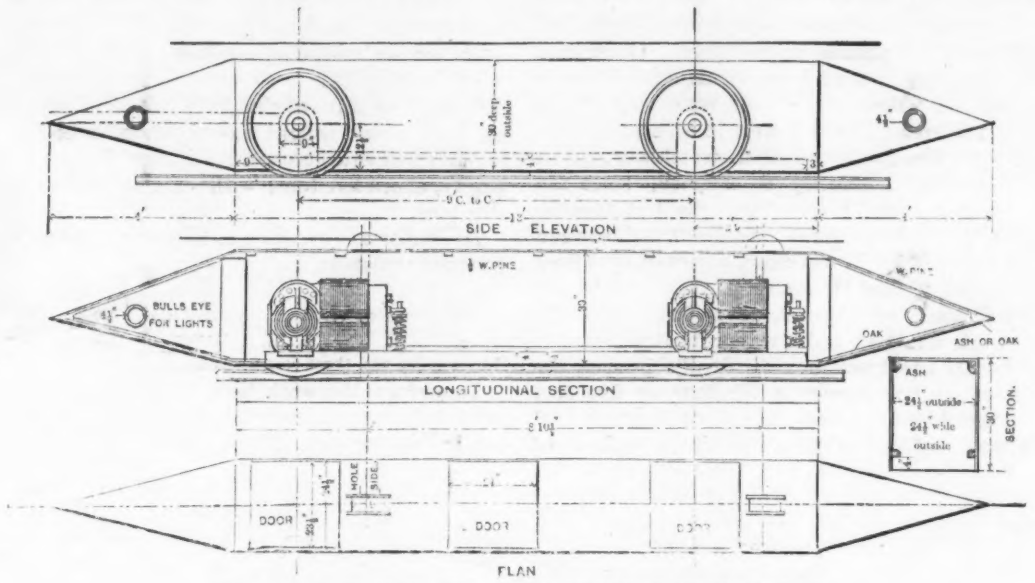


FIG. 1.—OUTLINES OF HIGH-SPEED RAILWAY CAR.

His persevering enthusiasm resulted in inspiring a number of gentlemen to subscribe money for the venture.

Mr. Weems first contemplated having an entirely automatic service from city to city, the cars to be smaller than would be necessary for placing a man.

For the purpose of demonstration, a circular track nearly two miles in circumference was laid at Laurel, Md.: gauge, 28 inches; weight of rail 16 pounds, shape T; cross-ties, 3×4 inches square, 16 inches apart. Wooden stringers, 3×4 inches, were laid outside each rail, serving as guards. Mud-sills, 3×4 inches, were laid under the ties, and to the ties was built up a vertical frame-work on both sides of the track, this carrying from cross-pieces a 2×6-inch wooden stringer, suspended above the middle of the track, while to the lower surface of the stringer was attached a small T rail, head down. This upper rail was intended to serve as an electric conductor, and also, in connection with upward pressing wheels, as a guide. The latter function was not successfully performed, the lateral oscillation of the car, on so slight a track, being too great. Part of the track was on trestle work crossing a swamp, the overflow of which caused frequent washouts.

The locomotive was very simple. Three axles carried 28-inch wheels; on these were hung a steel box 16 feet long × 24 inches high × 30 inches wide. A slight vertical play of the box was provided for by springs, but, horizontally, the three axles were in rigid connection. On each of these axles it was designed to place a motor. The head was pyramidal; the weight of the car with three motors was about three tons. A second similar box of steel was made to be drawn by the motor-car, the two to be connected by a ball-and-socket arrangement, the interval between the cars to be flanged over so that only one surface should be presented to meet atmospheric resistance. The tail was pyramidal. The second car was not in use more than once.

The track work and cars were completed as above outlined when the matter was brought to the Sprague Electric Railway and Motor Company, with the request that they design motors of which the armatures should be placed directly on the three driving axles of the car, the construction of which was already nearly finished. It was further conditioned that the motors should do 20 h. p. of work each at a normal speed of about 3,000 revolutions per minute. This corresponds to a car speed of about 250 miles per hour. Needless to say that on so light a track, none of which was straight, and with a car weighing three tons, and with only 60 h. p. available for work, no such speed was attained. The motors were carefully designed by Mr. H. F. Parshall, of the Sprague company, for a normal impressed E. M. F. of 500 volts, and thoroughly filled the specifications. They were to be connected in multiple across the 500-volt circuit supplied with current from a dynamo made by the Edison Machine Works. When the motors were finally mounted and ready for action it was found almost impossible to start the car, due probably to stiff bearings, and when several trials of speed had been made the results were disappointing.

Up to this time the electrical work had received only such engineering attention as could from time to time be given by employés of the Sprague company, much occupied in other ways. It became evident to the Baltimore company that any satisfactory accomplishment could be had only through the continuous attention of some one having electrical experience.

*A paper read at the fifty-fourth meeting of the American Institute of Electrical Engineers, New York, Feb. 24, 1891.

As superintendent of the Sprague company I had been familiar with the manufacture of the motors, and had moreover visited the plant; hence in October, 1889, it was arranged that further experiments should be under my direction. Throughout the work Mr. B. J. Dashiell, Jr., M. E., and Mr. H. F. Purdy, of the Sprague Electric Company, were of constant assistance both in conception and execution of all that was done.

Work having been resumed, it was soon found that a given speed could be attained with less current if two motors were in service than with three, and consequently the motor on the middle axle was removed. It seems probable that, when running, this middle motor was largely occupied in skidding the wheels driven by it, since the two outer axles, on a yielding track, would doubtless support the greater part of the weight. In any case, the two motors were able to produce a greater speed than the track could stand. These machines were of the U type. The armature was wound with 100 sections of No. 12 B. W. G. wire, each section of two turns. This armature, with its commutator, was rigidly mounted on the axle. The pole-pieces were attached to brackets centered on the axle; the keeper was spring-supported on a cross-piece carried by the steel casing. Bearings were of phosphor-bronze and lubrication was by oil from an ordinary cup. No trouble on this score was experienced. Each magnet core was wound with 120 turns of No. 4 B. W. G. wire. At 30 ampères the armature induction was about 80,000 lines per square inch. The outline of the motor is shown in Fig. 1. These motors, since wound according to specification for the 500-volt circuit, were originally connected in multiple arc. This connection was changed, they being placed in series, thus diminishing the potential control required at the station, by reason of the fact that the machines were run at a speed so much below that for which they had been calculated.

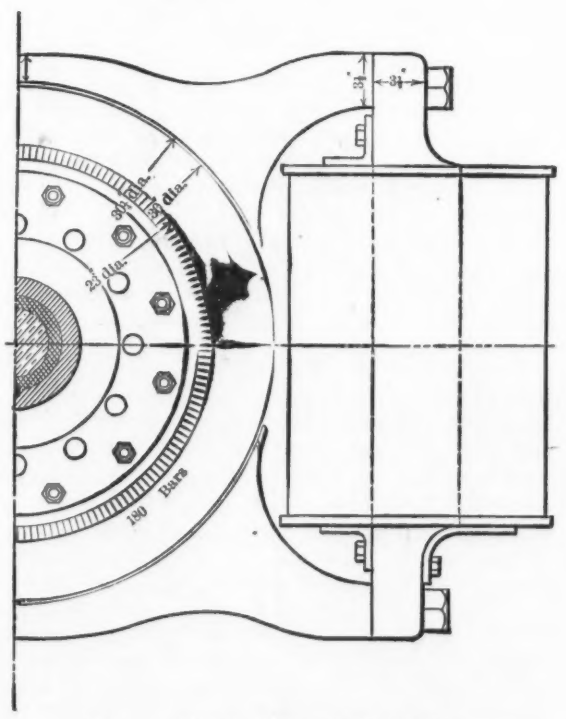


FIG. 2.—HALF END ELEVATION.

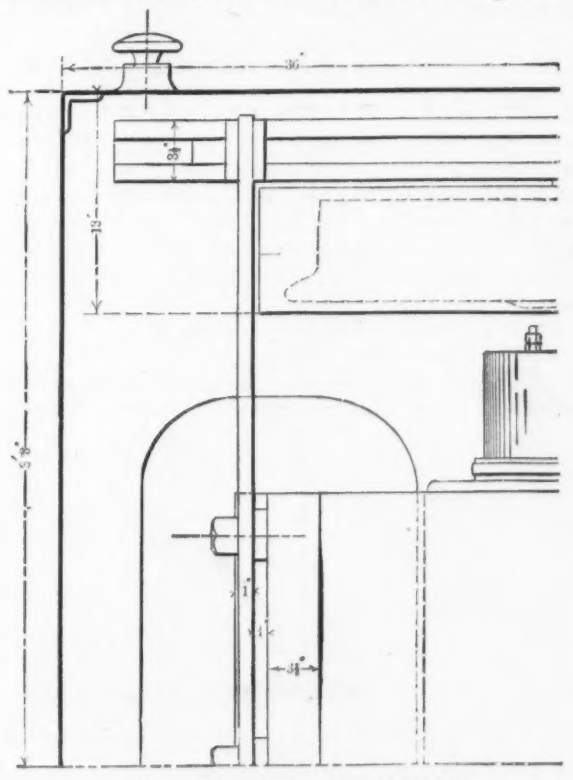


FIG. 3.—OUTLINE OF MOTOR.

To supply the current, contact was made between the upper rail and brushes of sheet copper set against the rail by springs. These served their purpose well. The return circuit was through the wheels and rails, the steel casing being insulated from the axle by fibre plates and washers at joints and bolts. Rail bonds (covering joints in upper and lower rails) were used throughout; the resistance of the external circuit from the feeder junction to a point diametrically opposite was about 0.25 ohm.

The station was placed inside the circle, about 200 feet from the track. The generator was a 70 h. p. Edison machine, not compounded originally, and was driven by a 90 h. p. high speed Ball engine. At first a wire resistance of about 12 ohms was used to lower the potential on the line, as it was not convenient to run the dynamos at less than 400 volts. Later, a whisky barrel was filled with water, an iron plate eight inches square was placed in the bottom, a similar plate was fixed to the end of an iron rod and this rod attached to the pulley, permitting easy lifting or dropping of the plate through the water. These plates being connected in the main circuit, a very serviceable liquid rheostat resulted, which, when "taken with a grain of salt," answered excellently the purpose of regulating currents which often went as high as 150 ampères.

The usual course of a run was this: Speed-observers, as many as could be had, up to five or six, were stationed around the circle, distance apart being known. Watches of these observers and of recorders who read current and potential were compared. Potential readings were taken at station and at one or two points on the line, permitting easy reduction to horse power. Mr. Dashiell, my assistant, then took the engine and I managed the dynamo. A current of from 20 to 40 ampères usually started the car. The size of the armature wires limited to about 90 ampères—45 in each machine—the current permissible for any length of time. This value was usually attained in the first half mile of run, a considerable part of the external resistance having been cut out. When the car had attained a speed of 75 to 100 miles per hour, the line potential was in the neighborhood of 450 volts, the iron plates in the barrel being in contact, having been slowly approached as the counter E. M. F. increased. The time limitation of the runs was invariably caused by failure of the track to serve its purpose. On three occasions the car left the track; once at 45 miles per hour, once at 80 miles per hour, and once, the last time, at about 115 miles per hour. Curiously enough, on the two former occasions the derailment was to the inside of the circle, super-elevation being about four inches.

It was easy to tell in the station when a derailment was imminent, as the ammeter was most violently agitated by the make and break of the circuit caused by the particularly bad spots in the track. The agitation increased with each trip round the circle, and ended in a run-off, or, after some experience had been gained, in a cessation of the trial. As the track limited the length of run in time, so also it limited the speed obtainable. Each trial—the longest being about twenty-two minutes consecutive running—was followed by an overhauling of the track, requiring from a few hours' to a week's work by four or five men.

Could the experiments have been made on a road-bed and track deemed even second-class according to steam railway standards of rail-weight, etc., there can be no question that, without any other change, the car could have maintained for several hours a speed of 120 miles per hour. Indeed, I know of no time limitation that would have arisen save that from a limited oil supply.

The speed obtained in the first round—that is in the first 9,240 feet—varied from 30 to 75 miles per hour; this determined by the management of the rheostat. The rate of acceleration from point to point in going round the circle was irregular, due to the grades, which, going in the direction usually followed, varied from 2.0 to 2.5 per cent.

The fact that the track—always bad—went rapidly from bad to worse during each run made it difficult to analyze the records with a view to determining the true coefficient of traction. Moreover, the coefficient for such a track, even in its best condition, would be greater than for the track that would necessarily be built for actual service. The figures obtained were of little worth as far as fixing absolute values at very high speed, but at least served

to show the error of many train resistance formulæ found in the text-books. Some of these formulæ give good enough results when used for the low speeds on which they are based, but their algebraic form is such as to give rise to great error when higher speeds—say 80 to 120 miles per hour—enter. This whole matter of train resistance has been more fully treated in a paper, "Limitations of Steam and Electricity," read by me before this Institute on May 21, 1890.* The particular element of atmospheric resistance, for which special experiments were made at Laurel, was fully treated in a paper read by me before the West Point branch of the Military Service Institute, and published in London *Engineering*, issues of May 31 to June 13, 1890.†

Using for atmospheric resistance figures resulting from the experiment herein referred to, we may analyze thus:

RUN OF OCTOBER, 1889. FLAT-HEADED CAR.

Time of 1st round, 3.8 minutes. Av. speed = 2,430 ft. per min. = 28 miles per hr.
Time of 2d round, 2.8 minutes. Av. speed = 3,300 ft. per min. = 37.4 miles per hr.
Average rate of work done by motors in 2d round = 15.0 h. p., 495,000 ft. lbs.
Average horizontal effort in 2d round = 495,000 ÷ 3,300 = 150 lbs.
Average horizontal effort in 2d round for atmospheric resistance = 30 lbs.
Average horizontal effort in 2d round for acceleration (approx.) = 10 lbs.
Average horizontal effort in 2d round for other resistances = 110 lbs.
" " " " per ton = 110 ÷ 2.4 = 46 lbs.

RUN OF NOV. 13, 1889. FLAT HEAD.

Time of 1st round = 4.25 minutes. Av. speed = 2,170 ft. per min. = 24.7 miles per hr.
Time of 2d round = 2.5 minutes. Av. speed = 3,700 ft. per min. = 42.0 miles per hr.
Time of 3d round = 2.5 minutes. Av. speed = 3,700 ft. per min. = 42.0 miles per hr.

The highest speed attained in this run was 90-95 miles per hour—track was very bad; car derailed.

RUN OF DECEMBER, 1889. WEDGE HEADED CAR.

Speed maintained at 100 miles per hour, with rate of work = 44 h. p. Moreover, some work of acceleration was done, but records do not permit accurate determination of this. Omit acceleration, and we have:

Average speed = 8,800 feet per minute = 100 miles per hour.
" horizontal effort = 44 × 33,000 ÷ 8,800 = 165 pounds.
" " " for atmospheric work = 48 pounds.
" " " for other work = 117 pounds.
" " " per ton = 117 ÷ 2.4 = 48 pounds.

Highest speed attained this run = 110 to 120 miles per hour. Track better than in last run, but car was derailed at maximum speed.

These values, 46.0, 42.5, 50.0, 58.7 and 48.0 pounds should be corrected for curvature, making them 30.7, 28.4, 33.4, 39.1, and 32 pounds respectively. Other and lower values were obtained when the track, as at first, was in better condition. But these earlier runs were not recorded in exact figures. The rails were in all cases rusty.

The maximum speed—that of final derailment, given above—could not be absolutely determined, since the car left the track at some distance from the last two observers, whose time record gave the speed attained between the points of observation. It was clear, however, that final speed was between 110 and 112 miles per hour. A length of 1,000 feet of track was injured, about 300 feet of the upper framework wrecked, and the car itself was landed about 30 feet from the track, having finally jumped the guard rails while going over a fill four or five feet high. It seemed clear that the Laurel plant had passed its days of usefulness. Nothing further of value could be done without practical rebuilding. It was then time to make new plans, and this work was at once begun by Mr. Dashiell and myself. At the outset I felt that—if for no other than commercial reasons—we should plan for the carrying of passengers as well as parcels. This meant an increase in the size of cars and a change from an attempt at automatic control to control by human intelligence on the locomotive.

For purposes of demonstration I proposed to the company that they should build a track about four miles (not less) in circumference, and should run thereon a train of two or three cars drawn by one locomotive. Calculations were based on the following data:

1. A speed of 150 miles per hour on a level was to be aimed at.

2. Cross-section of car should be a minimum consistent with the seating of passengers. This was taken at 6 feet by 5 feet, 30 square feet (crowning higher along middle of car).

3. Gauge of track should be standard—4 feet 8.5 inches.

4. Character of track should be simply the best that art could contrive, rails to be from 65 to 90 pounds.

5. Electromotive force should be as high as the art of insulation would permit.

6. Whatever might be the number of cars in a train, all were to be so connected as to present a continuous exterior, thus presenting only one cross-section to the atmosphere.

7. Atmospheric resistance at 150 miles per hour would be taken at 15 pounds per square foot of cross-section, a wedge or parabolic locomotive head being used. This value is 50 per cent. in excess of that indicated by our experiments.

8. Traction coefficient, exclusive of air resistance, would be taken, at 150 miles per hour to be 25 pounds per ton—this for reasons set forth in previous papers.

From the two resistance coefficients just given, it followed that for every square foot of cross-section, regardless of weight, six horse power would be required, and for every ton of weight, regardless of cross-section, 10 h. p. must be supplied.

For a locomotive of about 600 h. p. having 30 feet cross-section the dead weight was calculated to be about 18 tons. Steel cars of equal cross-section were designed, weighing, empty, about five tons, with carrying capacity of about five tons.

The important question as to power required could then be thus tabulated:

	150 miles per hour.	126 miles per hour.
Locomotive alone	360 h. p.	288 h. p.
Locomotive and one car loaded	460 "	369 "
Locomotive and two cars loaded	560 "	446 "
Locomotive and three cars loaded	660 "	528 "

To perform the work here indicated two motors were provided, one armature directly on each of the two axles of the locomotive cars. These motors, outlined in Figs. 2, 3, 4 and 5, were of the Manchester type. They were supposed to be at first connected in arc across a 1,500-volt circuit, each taking about 130 to 150 ampères, and delivering about 250 to 300 h. p. Should it be desired to experiment with higher line potential, the motors in series would permit 3,000 volts to be easily tried. The armatures of the Gramme type are 30 inches outside, 23 inches inside diameter. The armature conductors were to be of about 40,000 circular mils, cross-section, or from 500 to 600 centimetres per ampère. Many successful machines, designed to work indoors, go as low as this figure, and since the dissipation of heat must in such case proceed more slowly than in the case here considered, the figure seemed very safe. Moreover, it was intended to introduce a blast of air from the car front which should continuously flow through the open centre of the armature (Gramme type). How far the rate of dissipation would be carried by such means cannot now be known, but all recent evidence (see experiments of Mr. Kennelly*) goes to show that the heat capacity would be much increased.

The cross-section of core in the armature was 3.5 inches

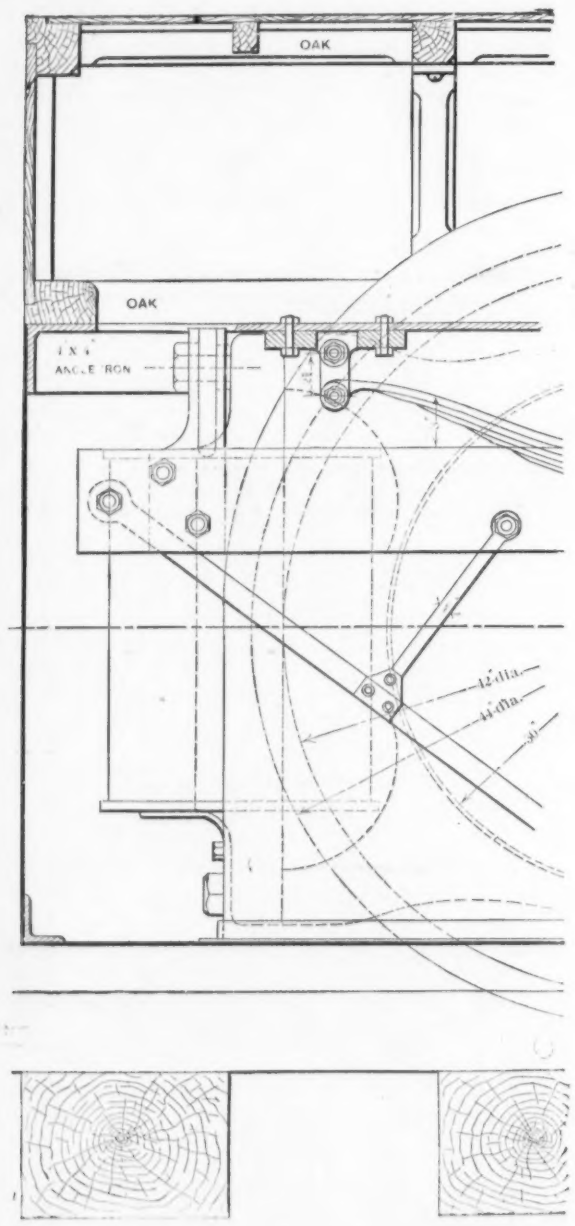


FIG. 4.—OUTLINE OF MOTOR.

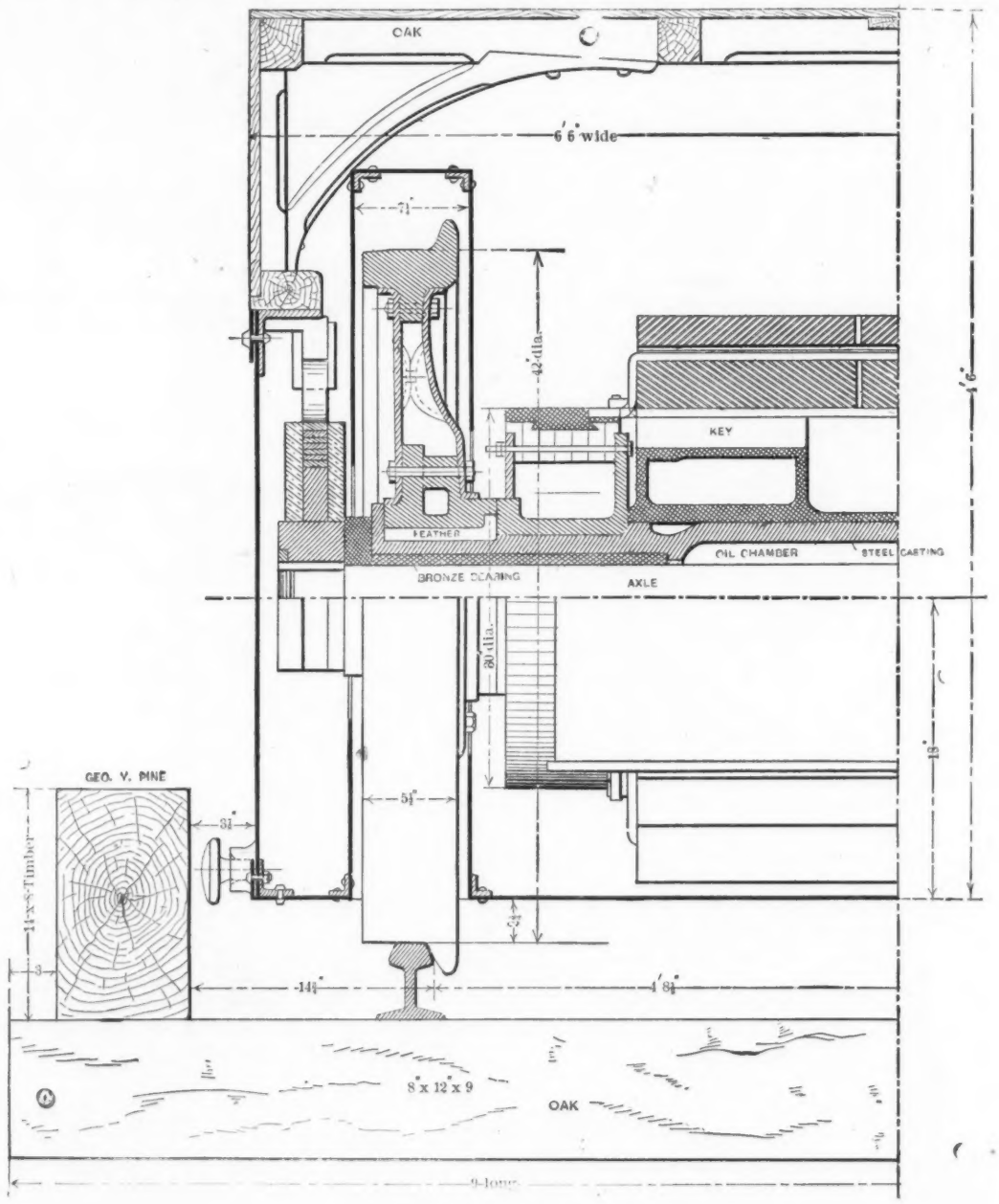


FIG. 5.—HALF CROSS-SECTION.

Av. rate of work from middle of 2d to middle of 3d round = 15.5 h. p. = 511,500 ft. lbs.
Average horizontal effort = 511,500 ÷ 3,700 = 138 lbs.
" " " for atmospheric work = 36 lbs.
" " " " acceleration = 0 lbs.
" " " " other work = 102 lbs.
" " " per ton = 102 ÷ 24 = 42.5 lbs.

RUN OF NOV. 13, 1889. PYRAMIDAL HEADED CAR.

Time of 1st r'nd = 4.0 m. Av. speed = 2,410 ft. per m. = 26.2 mls. per hr.
" 2d " = 2.0 " " = 4.620 " " = 52.4 " "
" 3d " = 2 25 " " = 3.678 " " = 41.8 " "
" 4th " = 2.25 " " = 3 678 " " = 41.8 " "
" 5th " = 2.25 " " = 3,678 " " = 41.8 " "
" 6th " = 2.25 " " = 3.678 " " = 41.8 " "
Average rate of work in last four rounds = 16 h. p. = 528,000 ft. lbs.
" horizontal effort = 528,000 ÷ 3.678 = 144 lbs.
" " " for atmospheric work = 24 lbs.
" " " " acceleration = 0 lbs.
" " " " other work = 120 lbs.
" " " per ton = 120 ÷ 2.4 = 50 lbs.

RUN OF DECEMBER, 1889. PYRAMIDAL HEADED CAR.

Time of 1st r'nd = 4.3 m. Av. speed = 2,070 ft. per m. = 23.5 mls. per hr.
" 2d " = 1.51 " " = 6,120 " = 70.0 "
Av. rate of work in 2d round = 41 h. p. = 1,353,000 ft. lbs.
" horiz'l effort = 1,353,000 ÷ 6,120 = 221 lbs.

" " " for atmospheric work = 38 lbs.
" " " " acceleration " = 42 " 80
" " " " other work 221 − 80 = 141 lbs.
" " " " ton = 141 ÷ 2.4 = 58.7 lbs.

* See THE ELECTRICAL WORLD, May 31, 1890.
† For an abstract of this paper see THE ELECTRICAL WORLD, May 3, 1890.

* See Mr. Kennelly's article "On the Heating of Conductors by Electric Currents" in THE ELECTRICAL WORLD, Nov. 23, Nov. 30, Dec. 7 and Dec. 14, 1889.

+ 40 inches = 140 square inches gross, or, deducting 15 per cent. for paper insulation between discs and eight per cent. for conductor slots cut in periphery, 110 square inches net. Through this armature it was desired to force 22,000,000 lines (C. G. S. units) or 100,000 per square inch = 15,200 per square centimetre.

The hysteresis loss in such an armature revolving at 1,200 revolutions per minute (equivalent with a 42-inch wheel to 150 miles per hour) was calculated to be about 3,000 watts—following the curve published by Esson. The C^2R loss (C = 135 ampères, R= 0.26 ohms when T = 75 degrees C.) = 4,740 watts—or about 8,000 watts for the two losses. I found it difficult to obtain such coefficient as would give reliable values for loss due to Foucault currents. With very thin plates it would not be large. From what precedes, it followed that the number of armature conductors should be 340. These were divided into 170 sections, wound in one layer, each conductor to lie in a slot; both slot and conductor were planned to be rectangular, or nearly so, with the reservation that experience in manufacturing would soon show the proper detail.

The magnets have a cross-section of 164 square inches, through which 14,300,000 lines of force must pass, the increase from the number in the armature being determined by a leakage coefficient 1.3.

The magnet coils of the two armatures were calculated to be in series with each other, but in shunt with respect to the two armatures. This variation from present street car practice I thought to be justified by the following considerations: First, no system of commutation could obviate the need of a considerable external resistance, which then could be easily made sufficient, within itself, for speed control; second, the maximum torque for a given armature current is always desirable and can be best obtained by permanent saturation; third, this constant and maximum magnetization would tend to diminish sparking—an evil to be specially avoided in long-distance work, involving continuous runs of several hours.

While it was thus intended to use shunt coils at first, I felt that a little experience would soon positively demonstrate that the advantage lay with this or the series winding.

The commutator (Fig. 5) was designed to be 23 inches in diameter, which would of course give rise to a very high speed relative to the brushes. I believed it better to face the mechanical trouble that might be connected with great circumferential speed rather than to diminish the diameter by decrease of sections, since this in turn might produce sparking.

Without going into the mechanical detail of the commutator, I may add that a single bar could be taken out or replaced without removal from the shaft.

The rheostat for the armature circuit was designed to be of iron wire, with the expectation, however, of experimenting also with liquid or carbon resistance. The resistance and heat capacity of this main line rheostat were determined with reference, first, to current necessary for starting, second, to currents needed for maintaining low speeds. The starting current on practically level track was calculated to be from 300 to 400 ampères, the load being 80,000 pounds (or locomotive and three loaded cars). For continuous running at 30 miles per hour, a current of 40 ampères would be required, the counter E. M. F. of each of the 1,500-volt motors being, at this speed, only 320 volts. The line-potential being 3,000 volts, it would be necessary to have in the armature circuit an external resistance of 59.0 ohms $= \frac{3{,}000-640}{40}$. The wires were calculated to stand 40 ampères continuously, and the various sections were proportioned to stand various currents for such time as would serve to bring the train up to speed. It was, of course, known that a considerable reduction in the size of the resistance box could be effected by winding the motors for the regular line potential, thus normally working them in arc, but putting the armatures in series where a great reduction in speed might be required.

A small rheostat and a condenser were designed to be placed in the circuit of the magnet coils, and a rheostat also in the lamp circuit, these resistances giving delicate control.

The problem of retardation for a mass of, say, 40 tons running at 150 miles per hour is a serious one. The Galton and Westinghouse tests indicate a very low value for the coefficient of friction between brakeshoe and wheel, at high speeds; they report it in some cases at 60 miles per hour as low as 0.04. As, however, it rapidly increases at lower speeds, an average of 0.1 may be taken. The total retarding effort, *i. e.*, brake resistance and track and atmospheric resistance, must be kept below that which will just produce sliding of the wheels, and the coefficient of sliding may be taken on an average at 0.08 of the weight of the wheels. If then we represent by P the maximum allowable brake pressure on the wheels, by R resistances other than brake friction, and by W the weight on braked wheels, we may write the following inequality:

$$0.1\,P + R < 0.08\,W.$$

The value of P should be determined as that which, with a small margin, will satisfy this condition of inequality.

Following this calculation it was found that a brake pressure of about 5,000 pounds should be applied to each wheel. This was designed to be produced by magnetic brakes similar to those used by Mr. Daft on the New York Elevated Railway. The form and approximate dimension of those brakes are shown in Fig. 6.

A mass of 80,000 pounds moving at 150 miles per hour represents 64,000,000 foot-pounds of energy. Average resistance due to brakes = 0.1 × 60,000 = 6,000 pounds. Average resistance from track and atmosphere for average speed of 75 miles = 400 pounds.

In addition, the motors may be required to generate a current which shall be wasted over the rheostat. Since the field-circuit in the case of shunt-motors is independent, magnetization may remain constant, and average E. M. F. of 1,500-volt motors (*i. e.*, motors generating 1,500 volts E. M. F. at 1,100 revolutions per minute, or, with 42-inch wheels, at 150 miles per hour) would be, while the train was coming to rest, 750 volts. Make the external resistance such that, the two armatures being in series, an average current of 200 ampères shall flow. Then average dynamo resistance in pounds = 2,000. Total retarding effort = 6,000 + 400 + 2,000 = 8,400 pounds. Dividing 64,000,000

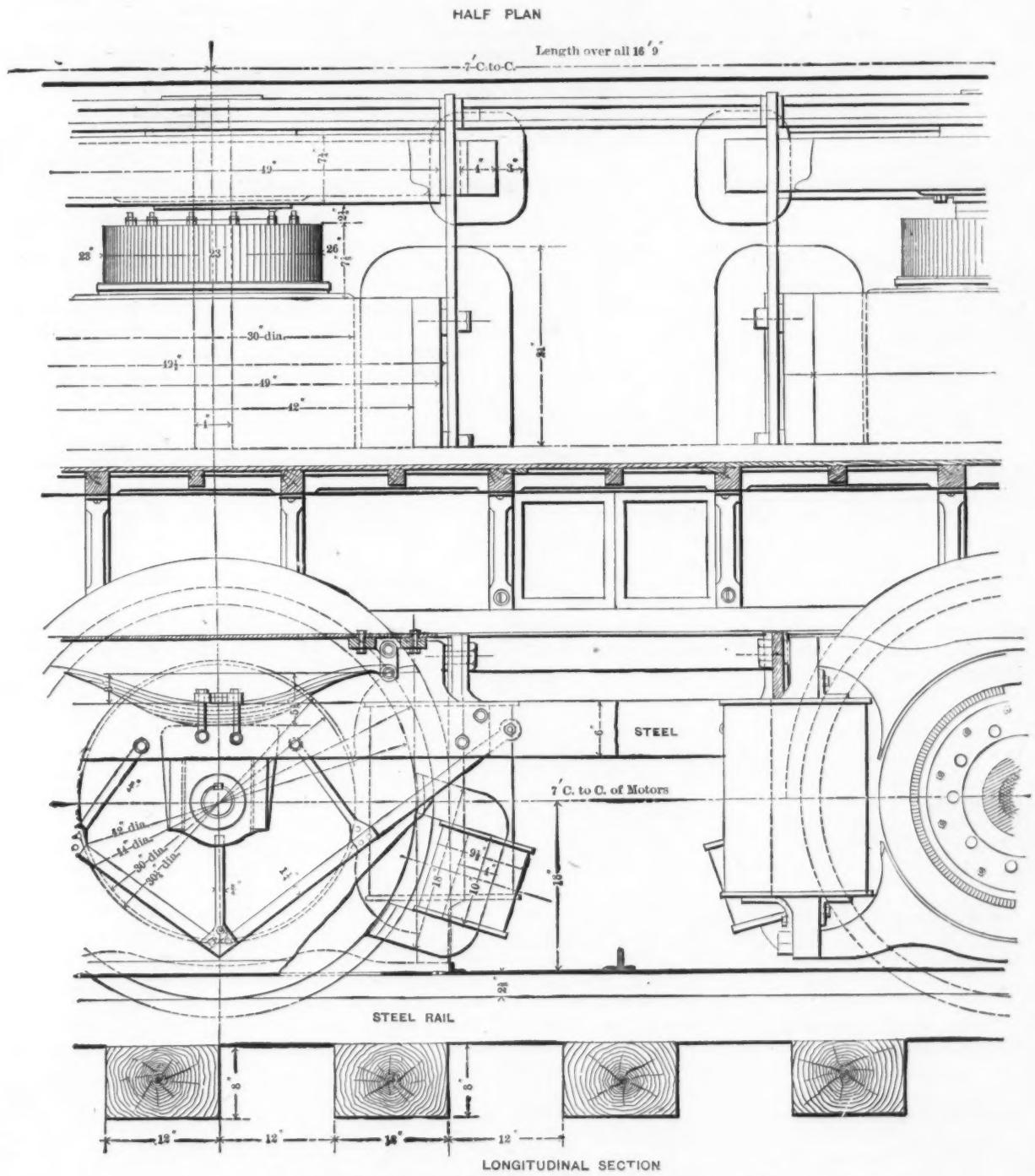


FIG. 6.—BRAKE MECHANISM OF HIGH SPEED CAR.

this, I did not overlook the fact that the armature must thus be subjected to much jarring. But I believe the difficulty should be met by excellent mechanical construction, rather than that spring movement should in any way be attempted. For mechanism that shall succeed in high speed, long-time service, simplicity is a requirement of the first order. Indeed, generally, in this work connecting an electrical motor to any vehicle, I have long felt that he who is over-ingenious in contriving many parts and fine adjustments may not be over-successful.

The weight of the magnets and pole-pieces goes also directly on the axles, save for the intervention of rubber plates having a maximum play of $\frac{1}{16}$ of an inch. By the use of motors of the "U" type, part of the weight might be spring-supported, but on the other hand it is not as easy with that type as with the Manchester to obtain a perfectly sparkless motor. Moreover, the weight going dead on the axles in the case considered is not greatly in excess of that due to 8-foot drivers and other attachments of large steam locomotives. Further, the need of any spring movement decreases with increasing perfection of track work; as, in ideally perfect track, car-springs would not, save on curves, come into play.

In the first design of locomotive cars, the operator is to sit between the two motors, where also would be placed the controlling devices. In the second design, the operator should be placed over the pony axle, the devices being chiefly in the cylindrical or parabolic head.

Detailed drawings of freight and passenger cars were completed, but need not here be referred to.

As to the supply of current, it is proposed to use the double metallic system. This departure from the ground return now so commonly employed in street railway work seems justified by the following considerations:

1st. For a given voltage it diminishes the cost of insulation, *per se*.

2d. It diminishes the danger of accident within the motors.

3d. It diminishes danger of accident to workmen.

4th. By being thus more easily handled it is probable that a higher voltage will be found practicable than with the ground return; hence in fact even first cost might not be greater.

As designed, the conductors will be placed in an inverted wooden trough, attached to posts placed at 12 foot intervals on each side of the track. The trough to be about 5.5 feet above the ground. The conductors for each side of

by this last quantity, we have 7,620 feet as the length of run to come to a stop, and the time of stopping about 100 seconds.

For the mechanical construction of the locomotive two plans were contemplated. One has a 12-foot rigid wheel base and no pilot wheels; the other has a 7-foot wheel base for the drivers and a pony axle in front, free to move laterally over a certain distance, dragging the drivers in the same direction. This is the general principle of pilot wheels, so largely used on high-speed engines. This second arrangement is preferred. In it nearly all the weight goes on the drivers. In this particular case the total weight of the locomotive is about 18 tons, each motor being six tons. Of the total, 15 tons rest on the drivers. If, then, the adhesion coefficient, while running, be taken at only 0.1, a circumferential effort of 3,000 pounds may be exerted without slipping the wheels. This is safe, since if 600 h. p. of work be required at 150 miles per hour = 13,200 feet per minute, the horizontal effort $= \frac{600 \times 33{,}000}{13{,}200} = 1{,}500$ pounds. For starting the load the adhesion coefficient may be taken at .25, giving 7,500 pounds possible pull, this being much in excess of the value required.

The locomotive construction is such as to put the entire weight of the armature directly on the axle. In designing

the circuit to be two—one insulated and continuous ; the other a bare, flat strip, broken into sections, these being normally out of circuit; the locomotive trolley-arm operating a switch which shall throw out the rear section and throw into circuit the section ahead. Such a switch was designed in detail.

As to what the line voltage should be, progress in the art of insulation can alone determine. It would, of course, not be necessary, on a roadway for long distance travel, to consider the death-producing voltage as a limitation.

In the important matter of limiting curvatures, calculations were made in the ordinary way, using the particular values for weight and height of centre of gravity. A safe speed was then tabulated as that which is just one-half the speed that causes the resultant of weight and centrifugal force to pass through the outer rail of a curve. The beneficial effect of super-elevation, neglected in the calculation, would, of course, practically increase the factor of safety.

The following table resulted from the method described:

Radius in feet.	Safe speed, by rule above, in miles per hour.
1,000	71
2,000	98
3,000	120
4,000	140
5,000	158
6,000	172
7,000	187
8,000	198

Of course, naught save practical trial could determine whether the assumed factor of safety, which is quite large enough at present speeds, would in fact be right for the higher speeds aimed at.

COMMERCIAL ASPECTS.

Copper calculations were made, based on a station potential of 3,000, and also of 6,000 volts, stations being 50 miles apart (thus supplying current 25 miles on each side) and on a service requiring one train on each 25 mile section, the drop on the line being 33 per cent. of station potential. Then for a line of 1,000 miles, as from New York to Chicago, with copper at 15 cents per pound, and for 3,000 volts initial:

Cost of conducting system, including frame work	$7,000 per mile.
Cost of station per mile, including steam	3,000 per mile.
Cost of double track, including depots, etc.	55,000 per mile.
Cost of train equipment, 3 cars each, 50 trains and engines	1,000 per mile.
Total per mile	$66,000

In this, the cost of track construction is based on roadbed figures reported for the Erie Railway Company. To arrive at operating expenses, suppose 20 trains each way each day, and a schedule of 125 miles an hour, *i. e.*, eight hours for the trip. Suppose a station development of 800 h. p. per train on the line, or 64,000 h. p. hours per trip. In stations of large capacity working under the supposed conditions, the cost of one horse power hour = 0.90 cent (see tables in previous paper "Limitations of Steam and Electricity*) or per trip, for power a cost of $57.60. For train men, suppose two men on each train, and one per train in reserve, and suppose $3 per man per trip of 8 hours, then cost per train trip = 3 × 3 = $9. Interest charge per train trip = $66,000,000 × 0.05 ÷ 365 ÷ 40 = $225.42. For maintenance of way (see Wellington's statistics) take $1,000 per mile of double track per annum, or per day for supposed line $2,700, per trip = 2700 ÷ 40 = $67.50. For general expense of operating company, suppose $1,000 per day--or per train trip $25. For wear and tear, oil, etc., on train itself, take $10 per trip. Then total = 56.60 + 9 + 225.42 + 67.50 + 25 + 10 = $394.42.

For receipts: Suppose average train be of two cars (such as designed), having each a capacity of about 10,000 pounds freight (considered such as express and mail matter), or of, say, 15 passengers. Suppose average train load of freight, 15,000 pounds; of passengers, 20. Take freight at 33 cents per hundredweight, passengers at $25. The income per trip in either case—$500, showing profits, over fixed charges of, say, $100 per trip, or $4,000 per day. The total daily load of freight each way required to justify the service above treated is 300,000 pounds, or if 200 through passengers be carried (*i. e.*, 10 trains for passengers each way each day), then only 150,000 pounds of freight. The *present* movement between New York and Chicago, in mail and express, is not far from this figure. A 500 mile line, connecting Boston, New York, Philadelphia, Baltimore, and Washington, would be even more profitable. It is to be remembered also that a service of small trains is contemplated, making fixed charges relatively very large. Much larger trains could be, and I think will be, run at the speeds here considered, but I have supposed that the smaller effort would precede the larger. It is further to be noted that the use of 6,000 volts of potential, and the extension of some existing roadway instead of the building of a new one, would diminish first cost. As grade crossings would be out of the question, and as cities would require to be entered above or below the surface (country roads to be carried over on bridges), it is perhaps best to consider only the larger figure already used.

To demonstrate all or nearly all that has been outlined in this paper will cost about $300,000, covering the construction and operation for a reasonable time of the four-mile circular line proposed above. Last year the Baltimore company met unexpected difficulty in efforts to raise the needed money; their operations were suspended and my connection with them ceased just at the time when plans were completed—even to working drawings. I have been much pleased to learn, within the last few days, that far from being discouraged, they are now confidently hoping that they may push on, in the near future, the great work to which they have laid their hands.

Unfamiliar as is the project, you will perhaps be the more ready to share the confidence of its promoters, on hearing the words from Prof. Henry A. Rowland and Dr. Louis Duncan, of Johns Hopkins, to whom were submitted, last spring, full details of the plans partially described in this paper. After reviewing the figures for power required they say:

"We believe from the data obtained that the values are not too low, and that the horse power which Mr. Crosby calculates is not less than the amount required. While we have investigated carefully and considered all the data obtainable, yet the existing experiments are not sufficient to accurately fix a limit to the train resistance. We believe, however, that the value assumed by Mr. Crosby is safe.

"The motors, the calculations and drawings for which are in the appended statement, will develop the horse power for which they are designed, namely 500 h. p. We point out some modifications which will be beneficial. We believe that they will drive the train* at the required speed.†

"The possibility of a train being derailed by an obstruction on the track increases with the speed. At speeds up to 90 miles, however, there seems no increase in the number of derailments. In the case in question, the centre of gravity of the cars is very low, and it would be difficult to derail them on straight parts of the track. The radius of the curves should of course be great, but not so great as would be required for an ordinary train going at these high speeds. The question of safety is, however, almost wholly a question of track construction. Considering the form of the proposed train, its comparatively light weight making á less demand on the track, it is certain that, with a carefully constructed road, it could attain with safety speeds which would be impossible with trains as at present constructed. As these latter have several times made 86 miles, and often made 80 miles, it would seem that a speed of 120 miles or even more, with the electric cars, would not be outside the limits of safety.

"The plan for supplying current to the motors is feasible.

"The design of the motors is discussed in the detailed report. It is generally good.

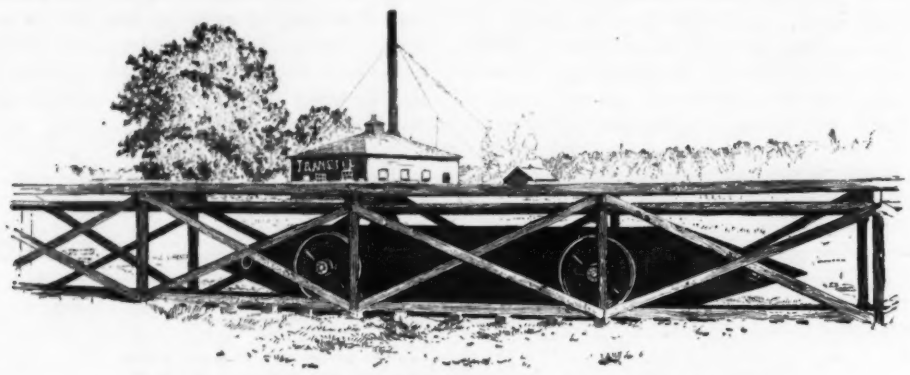


FIG. 8.—VIEW OF EXPERIMENTAL CAR AND TRACK.

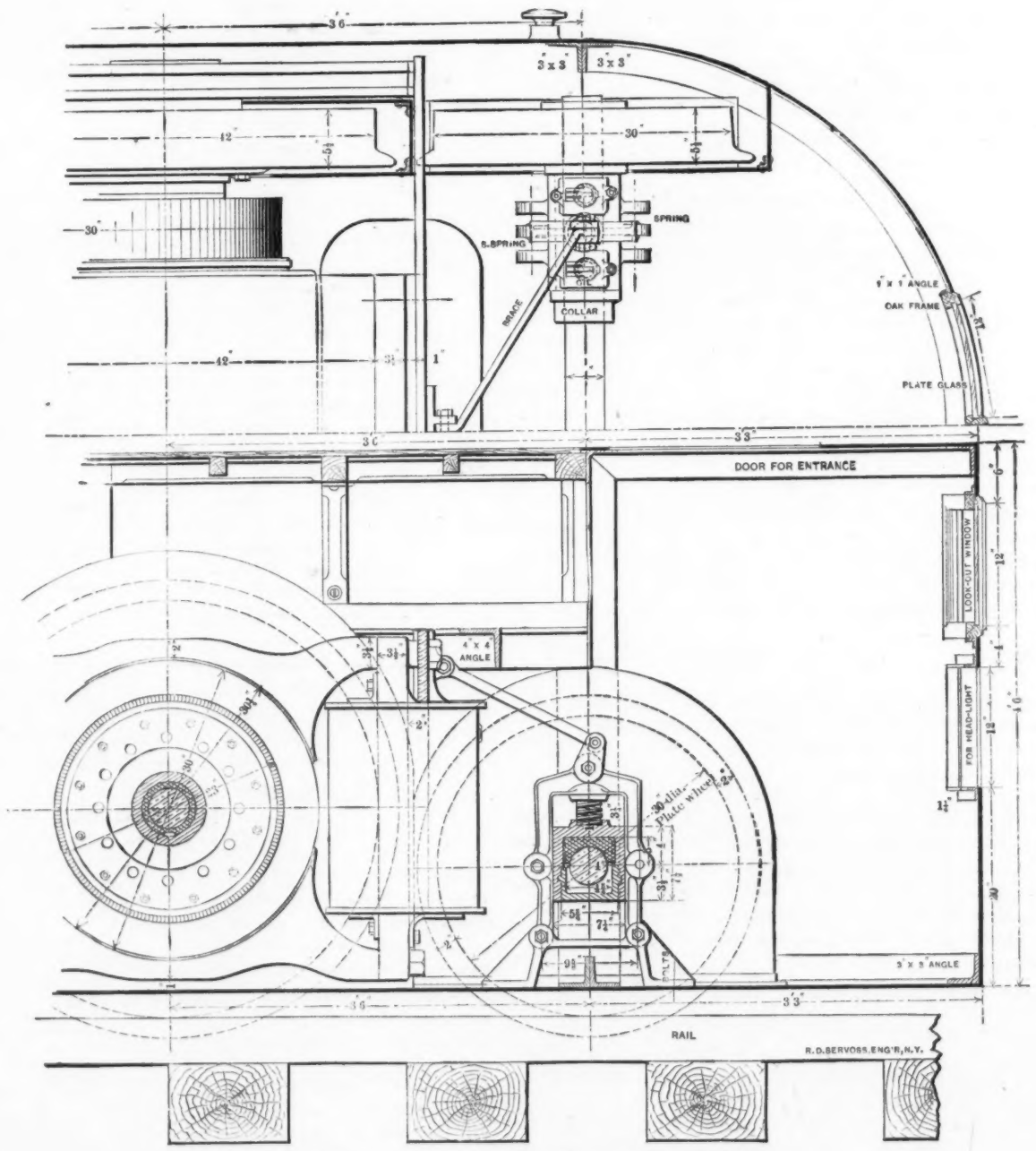


FIG. 7.—DETAILS OF HIGH SPEED CAR.

"Should it be demonstrated by an actual test that passenger trains can be run safely and economically at a speed over 100 miles per hour from here to Chicago, the financial aspects of the case would certainly be improved. We are of the opinion that the chances are in favor of this being accomplished by the present scheme."

These words, though guarded and accompanied by criticism of the detail, are yet a substantial approval of what was submitted. To me they were very encouraging.

* See THE ELECTRICAL WORLD, May 31, 1890.

* Locomotive and two cars.—O. T. C.

† Speed was then considered 120 miles on a level.—O. T. C.

[Pressure of other business has prevented me from carefully reviewing the calculations appearing in this paper.—O. T. C.]

Electricity as the Rival of Steam.*

BY DR. LOUIS BELL.

It is not my purpose here to discuss in learned phrase electrical science and electrical transmission of energy, nor to lead you into complicated studies of the practical details of the ways in which they employ electrical energy in daily life. I desire simply to put before you a common-sense view of some of the possibilities and limitations that present themselves when we try to make use of the potent force that is to-day becoming so important a factor in our modern civilization. But before discussing the properties of electrical energy, either for their own sake or for comparison with other things, let us delay for a little and attempt to establish in our minds some sort of definite idea as to what manner of thing electrical energy is, what its most prominent properties are, and how it is connected with the forces that are more familiar to us. We are to-day in a transition stage as regards our view of electrical action. Not so very many years ago scientific men were content to think of what they called electricity as a subtle fluid, to use the time-worn phrase, plastered, as it were, upon material things by certain processes, but with the extraordinary peculiarity that in applying one plaster another similar in some respects, but very dissimilar in others, invariably appeared on objects in the vicinity. In other words, electricity was looked on as a fluid that in some way was a mysterious attribute of the surfaces of bodies and produced remarkable effects on neighboring bodies: wherever a charge of the so-called positive fluid appeared another closely similar equal charge of hypothetical negative fluid must appear on bodies near by. The electrical current was looked upon as a flow of this extraordinary fluid through and along a wire much as water flows through a tube; and magnetism by a barbarous sort-of analogy was imagined to be composed of two other extraordinary fluids plastered upon the surface of iron and steel bars, and exerting marvelous pulls and pushes on other magnetic porous plasters in the neighborhood. I am going to ask you to-night to turn away from all this and look at the same fundamental fact from a totally different direction.

Now, in the first place, the thing with which we really have to do in every case of electrical action is not the indefinite something called electricity, but a very definite something—electrical energy. We have energy turning up in a great many different forms all about us, as heat, the energy of a falling body, the energy of something thrown, and in almost innumerable other ways. In the case of the energy of a cannon ball, for example, we find it can be measured by the product of the mass of the ball into half the square of its velocity. In looking at almost any other manifestation of energy we find that we can conveniently divide it into two factors, such as mass, velocity; force, and the distance through which it acts, and so on. Now, electrical energy into which we can at will transform the mechanical energy supplied by a steam engine is made up in a precisely similar way of two factors; one of these is potential, the other electricity. For most purposes we may think of electricity, whatever it is, as being only a coefficient of the potential, by which the latter is connected with electrical energy. What the physical meaning of this coefficient may be, in other words what electricity is, we are not prepared to state. It certainly, however, is not electrical energy itself, but only a part of it. Now, experimentally, in every case we are dealing with electrical energy, for we can hardly imagine such a thing as an electrical charge without a potential. If it really exists we have a very small chance of ever becoming acquainted with it, since we can only experiment by means of apparatus that requires a certain amount of work to be done upon it in order to show any indications whatever. Suppose we produce electrification upon any body by any means we choose, we shall find that the electrified mass will produce a series of pushes and pulls upon light bodies in its vicinity and all about it; in fact, throughout all the region without the body in question we find that there are a series of stresses, minute pulls and pushes, tending to act upon other bodies, and that the whole region is in a state of strain that can readily be made to show itself; a certain amount of energy has been taken from something to set up this effect, which really is potential electrical energy. Now, if we hunt around through the strained region about our electrified body we shall find that every piece of matter in the vicinity has been affected by the stresses that exist, and that its surface is, like the surface of the original body, electrified. Just what goes on at the surfaces themselves is of comparatively little moment, the interesting fact being that the whole region between them is in a state of strain from the electrical energy that has been furnished to it. We should, therefore, think of an electrified body not as having a surface charge of something about which we are totally ignorant, but as the centre of a system of stresses and strains; by stresses I mean forces acting, pushes, or pulls, or twists, or spins; and by strains the displacements, the effect in whatever is subjected to them.

So far as electrification goes, then, it is perhaps sufficient if we think of it as the manifestation of electrical energy that is found at the surface between media having different dynamical properties; just as we find a certain set of phenomena—reflection, refraction, polarization and the like—at the surfaces between two media that have different dynamical properties regarding light. The familiar fact that electrification is only on the surface of the conductor follows naturally from this view of the subject, and is only another way of saying that the stresses and strains produced by electrical energy change their character with the substance that is subject to them. Thinking, then, of electrification as merely a surface condition of the electrical energy acting through all the space outside of the surface, we can easily see the reason for some observed facts in electrical science. What we call lines of electrical force are merely lines which mark the direction of the stresses in the medium surrounding an electrified body. Where these lines of force—that is, stresses—act upon matter they produce some sort of strain in it of the kind that we recognize by its effects as electrification. It is quite needless to state that these lines of stress must either terminate in matter or close upon themselves; for one can hardly imagine such a thing as a strain with only one end, and if we can suppose the sort of strain that is produced by electrification—that is, the communication of electrical energy—to have a certain kind of endedness, as it were, it is not difficult to imagine the reason why the electrification at one end of the line of force is different in quality but the same in quantity as that at the other end. So we may sum up by thinking of electrification not as the production of a film of electricity on the surface of a body, but as the system of stresses and strains produced around a material body by expending electrical energy upon it. The lines of stress pass outward from the surface of the electrified body to other bodies, in which they produce electrification. In all this there is nothing revolutionary; we are merely looking at the two surface electrifications as terminating a stress in the medium between them.

Now, looking at a charge of electricity merely as a centre of stress exhibited in the medium outside, what will happen when that centre moves, as, for example, along a wire? Evidently the character of the stresses in the medium will be somewhat changed, depending upon the exact way in which the movement takes place. Now, as a matter of experiment, we find that when there is such a movement of the centre of electrical stress, as when what we call an electromotive force is free to act along a conductor, the result is a new set of stresses and strains corresponding to a spin of the medium about the direction of motion as an axis. This spin in the medium is a kind of kinetic energy, the particular kind we call electromagnetic; but if this view is correct, if we can produce electromagnetic stresses about a wire by letting a charge flow along it, it would seem probable that we ought to be able to produce a similar effect by moving the charged body rapidly through space without any conduction whatever. Such is the case, as was shown by some beautiful experiments of Prof. Rowland about 15 years ago. Now there is one curious case that can occur with these electromagnetic spins about the wire: suppose the electromotive force to be an oscillatory one, so that the charge, the centre of stress, will pass rapidly from one end of the wire to the other and back. You can see at once that the result would have to be a pulsating, wave-like strain in the medium, composed still of electromagnetic spins, but intermittent instead of continuous ones. These pulsations, waves of energy given off from the conductor, may be recognized by their effects as waves of electromagnetic energy. Like every other sort of strain, push or pull, or whatever it may be, these waves will move out from their starting point with a certain velocity depending upon the medium through which they are passing; in an enormously elastic medium the velocity will be very great, while in a dead, viscous substance the impulses will be transmitted but slowly. Now, as there will be a certain number of these pulses of energy per second, depending upon the rapidity of the oscillations that caused them, and as they travel at a certain velocity—never mind what it is—each electromagnetic wave may be said to have a definite length; in other words, each pulse will have traveled a definite distance before the next one starts. Now it is a very marvelous discovery, suspected 20 years ago, but only proved two or three years ago, that when these waves of electromagnetic energy are sent out with such rapidity that the length of each is only about the fifty-thousandth part of an inch, they come within the ken of our senses, and we have all been very familiar with them by their old name of light. If they become a little longer we feel them as radiant heat, and finally we come to such as may be produced by mechanical means, as in an alternating dynamo, where the waves would be something like 2,000 miles long. So we must recognize in light and radiant heat only forms of electromagnetic energy; or, rather, we find that they are the same kind of energy that we have been wont to call electromagnetic.

Suppose, however, that we have no waves, but only steady spins in the medium around the conductor, such as may be set up by the flow of electrostatic stresses, that I have described. The lines of force are then in circles around the wire, and if we coil up such a wire you will see that these circles interlock with the different coils, and we have a set of lines of force shooting through its centre. But such a coil of wire is a magnet, and the addition of an iron core only strengthens but does not change the character of the stress produced in the medium about it to any appreciable extent. So you see, starting simply with the system of stresses about a material that exhibits the kind of surface strain we associate with electrification, we may come quite easily to the idea of lines of force, having definite ends and producing electrification in other bodies; or, if we imagine the electrification to travel along a wire, it may produce electromagnetic waves, or steady electromagnetic force, which can be easily connected to the familiar form of magnetism. Meanwhile, we have scarcely mentioned electricity as such; in fact, inasmuch as we cannot experiment on it, since it is not electrical energy, but only a coefficient of it, we can form only very indistinct ideas as to its real character. We know only that what we call an electric charge produces, or accompanies, or *is* a superficial strain in matter, that becomes the centre of a system of stresses in the region outside of it, in which we find much to interest us. The important question is how to produce such a condition of things, for we know by experience that it has very useful properties, as may be seen in the manifold applications of electricity, of which I shall presently speak. In theory we can produce mechanical stresses that give an almost identical distribution of energy around the centre of disturbance; for example, if we had a tube open at both ends and immersed in a fluid, and then could suddenly start the fluid in this tube into motion, the lines of flow about the tube would correspond almost exactly with the arrangement of stresses about a bar magnet. A mass of jelly, distorted by a twist applied to a rigid bar imbedded in it, gives the same distribution of stress that is found in certain cases of magnetism. In similar fashion the electrical stresses may be imitated, so that at all events we need not have to imagine any enormously complicated mechanism for producing the state of things we find. Unfortunately, until we know very much more than at present about the intimate properties of matter, we hardly know where we should begin work upon it. However, both electrostatic and magnetic action can be very readily produced; in fact, it is very difficult to imagine any operation that can be performed on matter without transmuting energy into one or the other of the forms just mentioned.

In general, however, there are only two convenient ways of getting electrical energy in quantity. By acting chemically on the surfaces of certain metals we can start up, as it were, the kind of stress we call electromotive force, and get electricity flowing along a wire, but the more convenient method is to start with a magnet; all around it, as we have seen, there are stresses and strains in the medium, and the region where they exist we call a magnetic field. We have said thus far very little about the medium concerned, but we know that it is not air, for a vacuum is no obstacle to magnetism, and we know that it permeates all sorts of matter. From the identity of electromagnetic energy with light we know that the medium in question is what is often spoken of as luminiferous ether. Now, if we push a wire through this region of strained ether about a magnet we find, as might be expected, that the stresses react on the wire, and they actually set up that state of things which we call electromotive force; hence a current flows in the wire and the energy required to maintain it we have to furnish, and therefore the wire moves a little harder through the magnetic field than outside of it. Now, a dynamo is nothing in the world but a machine for dragging loops of wire through a magnetic field, and thereby setting up currents in the wires. The energy that appears in the current comes from the power that is pulling around the wires. It is just as when one drags a paddle wheel through still water, holding its axle lightly so that it may turn; the wheel can do work in turning, but you have to furnish the power by pulling it along—there is no energy acquired from the water. Conversely, if you pass an electric current through a wire that is in a magnetic field, and thereby set up spins in the medium about the wire, these will react on the stresses already in the medium and tend to fling the wire out of the field into a region where no stresses exist, or on the other hand to pull it into a place where the two sets of strains fit; this would correspond. in the hydraulic case we have just mentioned, with a paddle wheel floating in water and turned by hand; it will move along and push things before it, but the power has to be supplied externally. Here we have the principle of the electric motor, which you see is nothing but a dynamo working backwards. In either machine the important things are not the wires, or the iron magnets of the machine, but the actions and reactions set up in the medium that surrounds them. We can readily imagine a dynamo constructed without any iron at all, and, although it would be very inefficient, it would illustrate the principle better than if the iron were there. Our methods of designing dynamos and motors have been very carefully worked out at the present time, so that if we spin the armature of a dynamo we can recover as electrical energy from it fully ninety per cent. of that supplied by hand or water wheel or steam engine; and with a motor we can get back ninety per cent. again in electrical energy, if it suits our convenience. We have, then, very excellent means for transforming mechanical into electrical energy and the reverse. The question that is the real subject of my lecture this evening is: What advantages can we gain by employing this double transformation of mechanical

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energy to electrical and then back again? In other words, when will we be the gainers by this process, in which there must necessarily be some losses? What compensating advantages can we find?

As sources of mechanical power we principally depend on steam engines, or on water power; various other sources of power, prime movers we may call them, are now and then employed, such as gas engines, that have proved singularly convenient for some small work; petroleum engines, much of the same general character; hot air engines, used principally for pumping; water motors; wind mills, and a few others. None of these, however, can compete on a large scale with the steam engine, or with natural water power. Remembering this fact, that from steam or from water we must get our original supply of power, whether we use it directly or change it into the form of electrical power, let us look around and see under what conditions we can generate electrical current, use it in turn to produce mechanical power again, and be the gainers by so doing. One fact is really self-evident at the start; unless a given amount of power can be generated more cheaply at the point where the dynamo is driven than where the power must be finally utilized there is no direct economy in using an electric motor. In fact, the original power must be something like 20 per cent. cheaper at the dynamo than at the motor before the latter can compete directly with steam. I shall only consider steam or water driven dynamos as sources of electricity, since all the other methods of obtaining it are enormously more expensive; there is, in fact, no other practical way of getting electricity in quantity at all. We hope that there may be some day, but there is none now, nor do we know in what direction to look for it; we hear rumors now and then of electricity obtained from heat, or directly from chemical energy, but it has been shown over and over again that such methods, although occasionally convenient, are immensely more expensive than the usual one.

Now, under what circumstances can we use the electric motor and gain by it? To answer the question on the moment, there are three general cases where the motor is distinctly economical: (1) When power is ultimately to be used in small amounts and we can take advantage of the cheapness of production on a large scale; (2) where large amounts are needed, but from accidents of situation power can be obtained much more cheaply at some distant point than at the place where it is desired for use; (3) when for any reason it is laborious and inconvenient to produce power at the point of consumption. The first case is an exceedingly common one. Of a thousand places where power is wanted not less than 900 of them require it in very small amounts, less than a horse power. A little power is needed to run a lathe here; in the next block a horse power or two to operate a printing press; on a contiguous corner as much more to drive a bread mixer in a bakery; on the floor above it a half horse power to drive a dozen sewing machines, and so on. Now, we cannot produce power cheaply on a very small scale any more than we can most other things. In fact, the steam engine is singularly ill fitted for use where the power required is but little. It is an unfortunate fact that steam engines are not usually well made in the smaller sizes. It it a very difficult matter to get an engine of less than about 10 h. p. that will be as complete in all its parts and will compare at all in mechanical perfection with larger sizes. With the electric motor the case is very, very different; an eighth horse power motor may be as completely worked out in detail as one of a hundred times its power, and may be only slightly less efficient. Beside this, small engines are notoriously and unavoidably inefficient. All the sources of loss have a greater relative value as the size of the engine diminishes.

To pass from the general to the concrete, we can obtain a horse power for an hour—that is, power enough to raise nearly ten tons 100 feet high in that time—by burning under our boiler one and a half pounds of coal, provided we are using an engine of the most approved type and of something like 500 or 1,000 h. p. With smaller machines, of five horse power or less, seven to ten pounds of coal would be required to do precisely the same work. So we can see at once that the outlay for fuel alone would be five to six times as great with many small engines as with a single big one, and besides, while the latter can be run by a very few men, the time of forty or fifty would be taken up in caring for the 100 small engines accomplishing the same work. Of course, not all the power generated in an engine that drives a dynamo reappears in the electric current; there are small losses all along the line of operation. The friction of the engine alone frequently amounts to 10 per cent. of its full power, and if it is running at half load we can see at once that 20 per cent. of its power would be consumed in friction, because, as the load varies, the friction remains almost constant, being determined by the size and character of the working parts. Then, too, there are small but unavoidable losses that come from heating the wires, from stirring up currents in the metal work outside of the wires from which we obtain it, in friction of the bearings in which the armature turns and in doing magnetic work on the revolving core of the armature, which is made up of thin discs of sheet-iron impaled upon the shaft. Taken together, all these losses amount to about ten per cent. of the full output of the dynamo, and all of them except one—heating—remain nearly constant whether we are taking much or little current from the machine. Consequently, if the dynamo is worked at only half its full power, these losses become of importance. Altogether, for each horse power generated in the engine one is doing very well to get back four-fifths of a horse power in electrical energy from the dynamo. Still, taking into account all this, if we work on a large scale we can produce electrical energy on the whole very cheaply. It is not a difficult matter to figure out quite exactly, knowing the cost of coal, wages paid to employés and cost of plant, the net cost of each horse power hour produced. A convenient figure to remember is that, with a total capacity of 1,000 h. p., not less than nine-tenths of it being regularly utilized and working twelve hours per day, the cost of power in the form of electrical energy on the line is almost exactly one cent for each horse power hour; this includes everything—fuel, attendants, interest on the plant, depreciation of engines and dynamos, oil, waste and water. In a 100 h. p. plant, working under just the same conditions, the cost would be a trifle over three cents. So you can see at once the advantage of working on a large scale in producing power, and it is evident that even if there were considerable losses in distributing it by means of electric motors, there would still be a very considerable advantage in so doing. If the 1,000 h. p. station of which we were speaking is only used at a small portion of its full capacity, as I have just shown, some of the losses will be relatively much larger and the cost of power will be considerably higher. If, for example, only a quarter of the 1,000 h. p. were, on the average, to be used, the cost per horse power per hour would be very nearly double that which I just mentioned. Now, it is very easy to see that electric power under these circumstances is much cheaper than using small steam engines at the places where the power is wanted, even allowing a large profit to the company that supplies the electricity—as a matter of everyday practice a common charge for running electric motors is $6 per horse power per month; that is less than 25 cents a day. In taking out, then, a small steam engine and replacing it by an electric motor, there is gain at every point; at the price I have just mentioned five horse power could be bought for the daily wages of the man who would be required to look out for the engine and keep up the fire under the boiler.

The motor requires only occasional care, takes up very little room, is perfectly under control, and produces no dirt, dust, smoke or steam; and we must remember that with the engine there goes a boiler and a fire, both taking up room and requiring care, and somewhat objectionable on the score of safety. Where power is needed on a very small scale, a quarter or half a horse power, the advantages of the motor become more and more manifest. No one would think of building or operating in a practical way a half horse power engine, and if so small an amount of power were required, one would be driven to using a gas engine, or a water motor, neither of which can compete with the electric motor at the rate just given, unless in specially favorable situations. I hope, then, that I have succeeded in making it quite clear that in the case I have first mentioned, where power is required in small quantities, the electric motor is a very successful rival indeed of steam, because it is possible to produce power very cheaply on a large scale and distribute it by means of motors without excessive loss. Further, the electric motor is cleaner, more convenient and simpler than any description of gas or heat engine which has yet been devised.

Now, let us take up the second case, where a large amount of power is required, for which a steam engine could be very well used, but where it would be rather expensive to operate one; these conditions exist in very many places where it is desired to drive machinery at some point at which it is inconvenient or expensive to get coal. A few miles away, perhaps, may be found an available water power or a convenient coal mine or coal depot, where the price is low; in very many cases there will then be a decided gain in generating the power where it can be done more cheaply, and transferring the power as electrical energy through wires over across the country to the point where it is needed. Even supposing 50 per cent. to be lost in this transmission—a very large allowance—it often would be very economical. I know, for example, of a mining region in Colorado where power is necessary at each mine to drive stamp mills and other machinery, and where coal would be enormously expensive; five or six miles away from the centre of the mining district is a water power, a mountain stream shooting downward 300 or 400 feet; this fall is now being used to drive dynamos that in turn will distribute power to every mine that needs it, and some of them are a dozen miles away. In any given case where power is wanted it is no very difficult matter to figure out how much it will cost to run an engine to produce it; and then a counter calculation on the cost of obtaining the power from a distance electrically will show whether there will be gain or loss by using motors. In some cases, of course, there will be loss, in others, and many, a very considerable gain. So we are quite justified in saying that the electric motor may be cheaper than steam, even when the latter may be used on a large scale; the only condition being that we shall be able to take advantage of cheaper production by the ability electricity gives us to transfer power from a distant point. And finally we come to the third case, where electricity can be a successful rival of direct steam power—in situations where it is inconvenient or troublesome to get power by any other means. Fancy, for instance, trying to operate coal mining machines and drills in deep mines by steam engines placed at or near the point of operation. The difficulties of ventilation and danger of fire simply prohibit the successful use of engines, but wires can readily be strung and motors driven at 100 points from a distant power plant, and so we find that electric coal cutters and mining drills are gradually coming into extensive use, superseding the distribution of power by compressed air to a very large extent. Again, there are many situations where to use a heat engine of any description would be exceedingly inconvenient, or would bring down the wrath of the fire underwriters; here a motor can be safely boxed up and run in almost any position and under almost any circumstances with perfect security. Another example of the advantage that comes from convenience may be found in the many ways of using motors about the house to drive fans, to run sewing machines, to operate small pumps, and the like. Always and everywhere it is a power easily controlled, reliable and cheap; it can be led around corners by means of flexible wires, and moved about from place to place with the greatest freedom. It can be brought into play at a touch, and as easily stopped when the necessity for it is past; it can be regulated with the utmost nicety just to fulfill the demands that are to be made upon it, and can be trusted to go about its business almost automatically.

In all this we have seen that we must look upon electricity not in as any sense able to displace steam as a prime mover, but as an enormously powerful and convenient means of transferring power from one point to another with the greatest simplicity and very small losses. Probably for a long time to come by far the greater portion of dynamos will continue to be driven by steam engines, but so far as use at a given point is concerned the electric motor is a most successful rival of the steam engine. If the day ever comes, as it may—although we can hardly dare to look for it—when we can obtain electrical energy directly from coal, as we now obtain heat energy, the days of the steam engine will be numbered. As I have already pointed out, electricity and heat are very intimately related. Every time we heat a piece of iron, for example, we stir up not only what we call heat, but also electromagnetic energy, which is the form in which heat is radiated, and if we go on heating long enough we may raise the iron to a white heat, and recognize the energy in its familiar form of light. But all this is merely a dream of the future; perhaps it will be fulfilled some day, but until then we must depend upon our present dynamos.

In all that I have so far said you may notice with wonder that I have not alluded to the use of electricity as a motive power; to the electric street railway, or the magnificent possibilities of displacing the locomotive from its present supremacy. I have done this for the purpose of showing, first, what can be done with the motor as a stationary machine, and now, of course, you will understand that very much that is true of the motor at rest will also be true of it when it is employed in moving itself and drawing loads. It is merely a question of delivering a certain amount of power at a given point, and it is in this field, really a modification of the second case of which I spoke, that electric power presents some peculiar and almost overwhelming advantages. The ingenuity of inventors has been sorely tried in attempting to build a steam dummy that will perform successfully on street car lines. It is safe to say that nearly every such effort has come to grief, because an engine under such circumstances is not only working at a disadvantage, but is making itself excessively obnoxious to every one that chances to be on the same street. Here was the grand opportunity of the electric motor, that goes quietly about its business and can be applied at any one point, as well as many, provided it is duly supplied with current. So we connect the motor to the car axle and take current from a line strung overhead, by means of a traveling contact. For street car service the steam engine is almost out of the question, except as it is used in the cable railroad, so that the motor really does not have it for a rival at all. Young as is the electric railroad, the experience of the last three years has been sufficient to show that the horse must go. Whatever might be the relative cost of an electric road and the same system operated by steam dummies, about the comparison with horses there is no doubt, and the strongest evidence of this is the fact that nearly 300 electric roads are in operation or building to-day, operating over more than 2,000 miles of track. Wherever the change has been made from horses to electricity there has been a positive saving that will grow greater instead of less as improvements are made. The question is often asked whether the electric railroad can rival the cable road; in other words, whether the power can be distributed more cheaply by electric motors or by continuously moving cables. The cable is at the best where the line is short, straight, and generally heavily loaded, and under such circumstances is at least as economical as our best present electric railways. The improvements of a few years are likely, however, to reverse these conditions, and where the line is long and not heavily loaded the advantage is altogether on the side of electricity.

On Change of Form Affecting a Magnetic Field.*

BY PROFESSOR A. E. DOLBEAR.

Hitherto the study of a magnetic field has been the study of the so called lines of force radiating from the poles of magnets, either electro or permanent; and, so far as magnetism has been utilized in the arts, the changes in this external field have been brought about by the movements of an armature having for its function to determine the direction and consequent density of the field. Such is the case in the instruments used in the telegraph, the telephone, in dynamos and in motors. Sometimes conducting wires are so mounted in the field that their movements give rise to electric currents, which signifies that the energy producing the tension in the field is absorbed in some measure by the moving wires, and is transferred into an electric current. In each of these cases the magnet producing the field is stationary; that is, changes in the magnetic field produced by it are due to a motion external to the magnet itself, and may be that of an armature, of a moving wire, or of its own bodily change of position—a kind which is comparable with what is called external motion in thermodynamics, to distinguish it from internal motions, or such as take place when the body changes its form. So far as I am aware, no study has been made of the effect of changing the form of a magnetic body on its field, or of the reaction upon itself of its magnetic condition due to a periodic change of form. Of course, it has been known for a long time that the form of the magnetic field depended upon the form of the magnet itself. For a straight bar magnet, this field is familiarly known by the arrangement of iron filings forming curved lines from each pole re-entering the opposite pole. When the iron is bent into a U-form, or horseshoe magnet, the field is mostly contracted to the space between the poles. These forms of magnets have been *permanent* ones for the purpose for which the magnet was made.

In the case of induction coils, whether of one form or another, the magnetic change produced by it has been and is due to the *electric* change produced upon it by an electric circuit provided with intermittent or alternating currents.

Within a few years, attention has been called to the nature of the external field, as being a part of what is now known as the magnetic circuit, which consists of these *rings* or closed circuits of lines of force, all originating in the iron part of the circuit, and for *conducting* which iron is by far the best. The poles of the magnet are simply the parts of the iron where the lines enter and leave, and they may be in any place. Usually, they are at the ends of the iron, but not necessarily so. Whenever iron is placed in the magnetic field, these lines crowd into it, as it is a much better conductor than the ether. When the iron is made into a ring form and then magnetized, there is no external polarity, and consequently no external field, provided that the iron has sufficient conducting cross section at every part.

The following experiments have been tried, to determine what effects, if any, are produced upon a magnetic field by changing the form of the magnet. It was thought, at first, that if a helix was coiled into a circle, and a current was present in it, changes in its form would produce corresponding changes in the magnetic field external to the coil, especially noticeable if a flexible iron ring was inclosed in the helix so as to condense the magnetic field. This was put to the test in the following manner:

I. A coil, similar to the one described above, but containing a solid ring of iron, about eight inches in diameter and an inch thick, had its coil put in circuit with a reflecting galvanometer of low resistance, and at such a distance from it that magnetic fields external to its circuit could not act upon it. Another coil made about a flexible ring of iron wire was put in circuit with a battery so as to magnetize the ring strongly. Then, with one ring parallel to the other, the flexible one was made suddenly to assume an elliptical form. Each such change in form, from one ellipse to another at right angles to it, gave a deflection of the needle to the right or left, and uniformly for a given phase of change. It was also observed that the direction of the deflection was reversed when the flexible ring was turned the other side up.

II. The same flexible ring, used in the same way, but without the current through it, gave substantially the same results. Of course the ring was permanently magnetized, and the change might have been inferred.

III. As the same kind of motion, due to change of form, is taking place when a ring is vibrating at its harmonic rate, producing what we call sound vibrations, it was thought probable that a magnetized ring, having a coil of wire about it in connection with a telephone, would set up vibratory currents when it was struck; and this was found to be true, for when the coil containing the heavy iron core was put in circuit with a telephone in another room, the sound of the stroke and the pitch of the ring could plainly be heard. In the first case, the number of turns of wire was small, perhaps fifty or thereabouts. I therefore had two larger rings made, each about one foot in diameter and half an inch thick.

IV. One of these was wound with six or seven hundred turns of No. 32 wire. Before it was magnetized it was connected with the telephone and tested for its magnetic condition by striking. The ring could plainly be heard, which showed that it had some degree of magnetism.

V. Then about two hundred turns of coarse wire were wound upon it, and a strong current sent through it to magnetize it. After this magnetizing coil had been removed, the ring was again tested, as in IV. The sound was very much louder. Indeed, the telephone could be held a foot from the ear and be heard.

VI. With the ring in V. still in circuit, the companion ring, without any wire upon it, was brought near it and struck. The sound was easily heard in the telephone circuit.

VII. This recond ring was now magnetized in the same way as the first, when the magnetizing helix was removed and experiment VI. repeated. The sound was *very* much louder.

VIII. The ring was now struck and moved away from the first ring by stages of an inch or two at a time. It was found possible to hear its pitch in the second circuit when it was a yard or more away from it.

IX. As the pitch of the two rings was not quite the same, the higher one was loaded so as to bring them to unison. The sound was then louder and more persistent than before. This gave evidence that it was a case of sympathetic vibration, while the former were forced vibrations.

X. A common horseshoe permanent magnet, with legs about six inches long, had perhaps fifty ohms of No. 32 wire wound about the bend, and this was put in circuit with the telephone, and struck like a tuning fork. The sound in the telephone was remarkably loud, indeed too strong to be held comfortably at the ear.

XI. A coil of wire was now put about the middle of a piece of gaspipe, which was without permanent magnetism. The piece of pipe was about four feet long and five-eighths of an inch in diameter. This, when in connection with the telephone, was struck two or three times a second with a piece of brass rod, and while being thus struck it was rotated from the magnetic meridian to a position at right angles to it. The difference in the loudness of the sound, between the position in the meridian and away from it, was very marked. It is therefore shown to be possible to determine the points of the compass with a telephone, a coil, and an iron rod.

XII. A second flexible ring was now made, about a foot in diameter, consisting of a bundle of soft iron wire, the ends being roughly braided and twisted together; the thickness of this was rather less than half an inch. This was covered by a rubber tape wound spirally round it, the better to secure stability of form and insulation. Then 4.6 ohms of No. 21 wire were wound about it its entire length, making probably 1,000 turns. It was then magnetized by a current of about 1,300 ampère turns, leaving it a ring magnet. The terminals were then connected with the terminals of a reflecting galvanometer with a resistance of .67 ohm. Very slight changes in the form of the ring, either by pulling or pushing, gave decided movements to the needle, while larger amplitude gave 30 to 40 degrees deflection.

XIII. It was noticed, also, that the direction of the current depended not only upon the direction of the motion changing the form, but also upon the direction of the motion with reference to the normal shape of the ring. Thus, if the ring be a circle, and it be drawn into a horizontal ellipse, the current will move the galvanometer needle, say to the right. When it is brought back to the circular form the current is reversed. If the motion be continued so as to produce a vertical ellipse, the current will be in the same direction as that produced at first by a motion exactly opposite in direction, so that for a complete cycle of vibratory changes four currents are generated, two direct and two reverse.

XIV. One of the iron rings before mentioned, a heavy one about eight inches in diameter and an inch and a half thick, having coarse wire wound upon it nearly covering the ring, was connected with the galvanometer as before, and the ring was struck by a brass rod. The needle instantly swung through a wide angle. Struck again it moved as before, but not through so wide an angle, and a half-dozen blows knocked nearly all the magnetism out of the ring. This was then detached from the galvanometer and magnetized as before, when it again gave the same large deflection it gave at first. The same conditions were tried with other rings, and in each case it was found that a vigorous stroke upon the ring magnet had the same destroying effect upon the magnetism as it is known to have upon magnets having external fields.

XV. The flexible ring was now put in circuit again, and vigorously jerked with the hands. A very few such movements served to destroy nearly all the magnetism present, requiring the remagnetization of the ring.

As flexible iron rings such as I wanted were not easy to make, I procured some steel wire rope of the right size, and the ends were welded for me through the courtesy of Professor Elihu Thomson, of Lynn, by his electrical welding process. Such a ring about a foot in diameter allows a movement of five or six inches to one of its sides. This, when wound with four or five hundred turns of No. 22 wire, may be magnetically saturated by sending a current through the wire, leaving the ring charged. The terminals may now be connected with a proper galvanometer, and changes in the form will discharge the ring.

These experiments prove:

1. That a change in the form of a magnet causes a corresponding change of stress in the field.

2. That periodic changes in form due to elasticity of form, such as are called sound vibrations, set up similar periodic changes or waves in the magnetic field.

3. That such sound vibrations of a magnet act upon other magnets like sound vibrations, and set them into corresponding vibratory movements, sympathetic or forced: sympathetic when the receiving magnet has the same pitch as the transmitting magnet, and forced when it has not the same pitch.

4. That such sound vibrations in the receiving magnet cause a corresponding change of form in its magnetic field, which manifests itself by currents in surrounding circuits.

Sir William Thomson has frequently said that he could understand a mechanical idea when he could make a model of it, but could not otherwise. If one assumes that the ultimate atoms of iron are magnets, as is thought most probable now—or holds, by Ampère's hypothesis, that currents of electricity circulate about each atom, making it a magnet—in either case, each idividual atom has its own magnetic field, which is, necessarily, always with it. It is really its reaction upon the other. If such atoms be elastic, as there is the best of reasons for believing, then it follows that impact must set them into periodic vibratory motion; that is, periodic change of form at a rate depending upon its degree of density and elasticity. Such changes of form set up corresponding periodic waves in the ether, as changes in the magnetic field, and these are transmitted outward with a rate depending upon the properties of the ether to transmit such motions, not upon the source of the disturbance.

Such vibratory motions among atoms and molecules we call heat, and such periodic waves in the ether we call light, and thus Maxwell's idea of light being an electromagnetic phenomenon is altogether in accordance with the experiments. For waves of the lengths of light waves, it is essential that the vibrating body be small and highly elastic. Maxwell's idea was, that the opposite phases of ether waves could produce opposite electrical efforts, so that each half-vibration represented either positive or negative conditions; and these implied, though I have not noticed the statement, that they must have originated with vibrating magnetic atoms or molecules. It has been difficult or impossible heretofore to imagine how ether waves could be set up by vibrations of the elements, though the idea that the atoms of matter are magnets is not new at all, and has a good degree of probability. If one is to picture to himself at all how this kind of a phenomenon can occur, he is bound to have in mind some form for an atom that shall at the same time be a consistent magnetic form. If atoms are magnets it is wellnigh inconceivable that they should be spheres or cubes, or tetrahedra or discs, or any of the ordinary geometric forms, for such would be very poor forms to exhibit magnetic properties. But a ring presents a very different case, as a ring magnet is the most perfect form possible. There is this to be said of such a form, however—it does not present what we commonly call a magnetic field; it is a closed circuit. Nevertheless, I would ask if it is probable that the ether external to a magnet of that form should be quite unaffected, quite neutral. I should suppose not, but, on the contrary, should look for some sort of stress there, though it might be of somewhat different nature, and have somewhat different properties from an ordinary magnetic field. But if such were the case, it follows that any magnetic change in the ring magnet itself would be followed by a corresponding change in the external field, and vibratory motions would necessarily set up waves in that field. Such waves would have a magnetic origin, but the waves themselves would not necessarily give rise to electromagnetic effects directly. Indirectly they would, for if they could make another similar magnet vibrate sympathetically, these vibrations would react upon its magnetic properties.

Such a ring form as I have shown suggests at once the vortex ring theory of atoms, of the properties of which I have so often spoken to the Academy. Perhaps the experiments should have a different interpretation from that suggested here; but whatever their interpretation may be, they are believed to be entirely new, and therefore of interest, if not important.

*From the Proceedings of the American Academy of Arts and Sciences.

Welding Glass and Porcelain to Metals.

M. Cailletet, according to the London *Electrical Engineer*, has communicated to the Société de Physique a method of welding glass and porcelain with metals, which may prove extremely useful for instruments of research, or for any metallic fitting, such as taps, communicating tubes, conducting wires, etc., so as to avoid all leakage even under high pressures. The process of welding is very simple. A portion of the tube that is to be welded is covered with a very thin coat of platinum. To obtain this deposit it is sufficient to paint, by means of a small brush, the slightly warmed glass with completely neutral chloride of platinum, mixed with essential oil of camomile. The essence is made to evaporate slowly, and when the white and colored vapors have ceased to be given off, the temperature is raised to dull red heat, and the platinum being reduced covers the glass tube with a brilliant metallic coating. Connecting the tube thus metallically coated to the negative pole of a battery of suitable energy, it is placed in a bath of sulphate of copper. A ring of copper is deposited upon the platinum, and strongly adheres thereto if the operation has been properly carried out.

Physiological Effects of Alternating Currents of High Frequency.

BY ELIHU THOMSON.

In connection with an experimental investigation of the properties of alternating currents of high frequency and the phenomena which they present, it had occurred to me that it would be desirable to obtain data concerning the physiological effects of these currents as compared with the effects of currents of ordinary frequency. I had constructed a machine on the type of my new alternating dynamo, accounts of which were published some time last year. In this machine an iron mass only is revolved, the central portion of which carries projections which pass near to the coils in which the currents are induced, which may be termed the armature coils, carried on the inner face of a laminated structure, in turn supported by the outer framework of the machine. The machine with 100 armature coils and a speed of 5,000 revolutions per minute gives a little over 8,000 alternations per second. The publication of brief notices of some of the results obtained in the operation of this machine led Dr. Edward Tatum, of Yonkers. N. Y., to correspond with me with the view of finding out whether I had intended to conduct any physiological experiments with the currents, and indicating his desire to experiment in this direction if the machinery for obtaining the currents could be placed at his disposal for a short time. Accordingly, the machine was sent to Dr. Tatum some time last fall, and was used by him in making a series of experiments, the results of which cannot fail to be of the highest interest to electricians and physiologists. Very unfortunately, Dr. Tatum has been an invalid since January last, and has therefore been prevented from writing up the results which he obtained, some of which were transmitted to me in a letter dated Dec. 29, 1890, before he was taken sick. I will say here that Dr. Tatum had intended to continue his experiments further before publishing any results of the trials. I quote from Dr. Tatum's letter as follows:

"The most definite, and perhaps the most striking, as well as physiologically instructive result, has been in regard to the fatal efficiency of such rapidly alternating currents. When the circuit is formed through the head and body (of dogs) death occurs in the same manner as with other sources of current (which are made strong enough to kill by a closure lasting not more than two or three seconds), that is, by primary arrest and paralysis of the heart, but taking the fatal efficiencies of different sorts of currents as inversely proportional to the current strengths required to kill under otherwise similar conditions, a rate of 4,500 per second is not only far less efficient than rates of a few hundred, but it is distinctly less efficient than a continuous battery current. Indeed, in four of the five dogs that I have killed at the high rate a stronger nominal current was survived than I have ever before used (with a single irrelevant exception) to kill a dog. A nominal current of 1.35 ampères was entirely recovered from; the animal on the following morning showing no signs of physical or mental disturbance. This is four times the strongest fatal current at 300 alternations that I have used on normal dogs; six times the strongest current survived, and 13 times the weakest fatal current. It is 13 times the strongest fatal current used at 120 alternations; 20 times the strongest current survived, and 18 times the weakest fatal current. It is remarkable that rates of 300 and of 120 alternations per second are fatally efficient at very nearly the inverse ratio of the numbers; but still more remarkable that the very highest rates should also present a strikingly near approach to a similar ratio. It must be noted, however, that no such ratio can hold throughout the whole range, for 36 alternations per second (from the same machine as furnished 120 and the 300 rates) are again distinctly less efficient than 120--something like two-thirds as efficient."

Dr. Tatum goes on to point out that a potential of 450 volts was survived at the high rate of alternations and the fatal current only reached at 495 volts, while 45 volts at 120 alternations similarly applied to the dog suffices to pass a fatal current. Dr. Tatum also determined the ratio of pressure or potential to current in the dog just after the cessation of respiration, using in rotation, twice repeated, first a continuous pressure or potential, secondly, an alternating one at a rate of 120, and, thirdly, an alternating potential at a rate of 4,500 per second at about 100 volts, and states:

"This ratio was so uniform (the extremes observed differing by less than three per cent.) as to dispose of any suspicion that the high-period currents distributed themselves essentially different from others in the animal's body."

I will continue to quote from the doctor's letter, as the results he obtained could not be so well expressed by myself as he has done in relating them.

". . . In regard to the physiological as distinguished from the fatal characteristics of the high-period machine, I am only able to state the results in terms of pressure instead of terms of current, as I should prefer. The limits of voluntary toleration for alternating pressures (applied with sponge electrodes) seem to depend very little on the frequency of alternation. For all the frequencies I have mentioned the limit has been found between 10 and 15 volts for applications about the face and head, and between 40 and 50 volts between the hands . . . without any decided preference in either case for one rate more than another.

"The cause of the pain which limits voluntary toleration seems to be in all cases chiefly in the muscular contraction produced. At 4,500 this muscular contraction is usually free from the thrill experienced even at 300, resembling on the temples nothing I can think of so much as a firm pressure with the knuckles. The cutaneous nerves are distinctly less painfully affected at the high rate. The visual mechanism cannot be excited at the high rate even by a pressure of 15 volts, so as to cause a sensation of flashes of light, although two or three volts similarly applied at 120 alternations causes such flashes very energetically. The sensation of dizziness caused by a few (four or five) volts applied behind the ears at a low rate of alternation of current cannot be produced at the high rate. Sensations of taste are also absent. Directly applied to the exposed motor nerves and muscles of dogs and frogs, pressures at high frequencies seem less efficient as stimuli than at lower frequencies, in something like the same ratio as their killing power. The establishment of anything like an exact ratio I have not accomplished, owing partly to the very low pressures, which acted as very energetic stimuli when applied directly to fresh nerves. Thus a nominal potential difference of one-twentieth of a volt in a length of nerve of eight millimetres of a frog's sciatic nerve still causes vigorous reaction. As the proportions lose their vitality, however, stronger and stronger stimuli become necessary to elicit a response, and it is during this period of failing vitality that something like the above proportion is indicated between the respective pressures required to just produce a visible reaction."

Dr. Tatum's letter also contains references to the work which he had planned to carry out in the near future concerning the relations of alternating currents of high period to vital structures, which work he has been, I regret to say, prevented from pursuing by his sickness, from which he has not yet recovered.

He also makes the inquiry as to the practicability of constructing a machine to deliver currents at a rate of 40,000 to 50,000 per second, such machine to be used in continuing the investigations, some of the results of which are given in his letter.

I take great pleasure in being of service to Dr. Tatum in presenting some of the results of his very able investigations, feeling sure that they cannot fail to be of the highest interest to physicians, electricians, and many others. In presenting these results I take occasion to express my sincere regret that ill-health has prevented the continuance of the work in the direction laid out by the doctor himself, and to express, also, the hope that he may be able to take up the further investigations at some other future time.

The Electric Transmission of Power.*

When the modern storage battery was first introduced we were told that in future we should have electricity delivered to our house every morning like the milk. Each day a few freshly charged cells would be carried into our cellars, and those that had been exhausted would be taken away to be refilled. This pleasant prospect has not been accomplished; storage batteries larger than toys are very seldom carried from place to place as sources of light, while it is only one or two tramway companies that regard them as a convenient vehicle for storing and transmitting power. It is quite clear that such heavy and bulky appliances cannot be handled and transported cheaply, but hitherto no one has taken the pains to calculate for us exactly how much it would cost per horse-power hour to transmit, by means of storage cells, the power of a waterfall to a distant point where it could be utilized. Last Monday night, however, Mr. Gisbert Kapp took up this subject in the first of his Cantor lectures, delivered before the Society of Arts, and worked out results that cannot fail to attract the attention of all persons who take an interest in the transmission of power by electricity.

Let us suppose that the source of power is a waterfall, and that there is erected beside it a turbine driving a dynamo which is used to charge storage cells. These cells are afterward transported along a tramway to a mill, where they are employed to drive an electric motor. Their carriage is effected by a car which is itself driven by a current from some of the cells, a part of the stored energy being thus used both on the outward and return journey. It is clear that each mile will use up a certain percentage of the stored power, and that if the distance were sufficiently great the whole power would be expended in transit backward and forward, making the efficiency of transmission equal to zero. Mr. Kapp calculates that a journey of 10 miles on a tramway would require the expenditure of 10 per cent. of the stored energy. The unwieldiness of storage batteries is clearly shown by comparing the distance they can be carried with a 10 per cent. loss (90 per cent. efficiency of transmission) with the distances corn and coal can be carried with a similar loss. The corn would be drawn by a horse that lived on it as he went along, and the coal hauled by a steam engine the boiler of which would be fed from the coal it drew after it. The horse may be assumed to draw his load at the rate of four miles an hour, whether on road, tramway, or rail, while electric and steam traction would take place at four miles an hour by road, six miles an hour by tramway, and 20 miles an hour by rail. The results are given in Table I., and are calculated on the hypothesis that the roads are all alike, flat and straight, and that there is no stopping and starting between the termini. On these assumptions coal can be carried 1,300 miles by rail by the consumption of 10 per cent. of the energy stored in it, while accumulators can only be carried 26 miles. In an electric tramway on the battery principle these favorable conditions of absence of curves and gradients and continuous action could not be found. Further, a load of 3½ tons of passengers has to be moved by 2½ tons of batteries. In practice it is found that the entire charge is expended in from 30 to 60 miles.

TABLE I.—TRANSMISSION OF STORED POWER.

Source of Power.	Distance in miles attainable with 90 per cent. efficiency of transmission over		
	Road.	Tram.	Rail.
Coal and steam engine.....	115	270	1,300
Corn and horse.....	52	170	440
Storage battery and electromotor..	4	10	26

The cost of water power varies from £2 to £8 per h. p. per annum, according to the amount of work necessary to render the power available. Steam power is reckoned at £10 per horse power per annum in large installations, working ten hours per day or 3,000 hours a year. In small and uneconomical plants the cost of steam power may run up to £20 or £40 a horse power. It is, therefore, evident that on a large scale it would be quite impossible to transmit water power costing anything like £8 a horse power to compete with coal. Further, since the effi ciency of battery transformation is only 58 per cent., or in other words, since 172 h. p. in the turbine will only yield 100 h. p. at the motors, the cost of the water power must be very low to render it possible to transport it. Let us take it at £3, and add all the other charges for wages, interest, depreciation, etc. At £30 a horse power (the present charge is £40) two batteries of 111 h. p. each would cost £6,600; interest and depreciation at 15 per cent. would amount to £1,000, making the cost per horse-power per annum for interest and depreciation alone £10, or the same as the total charge for steam power, including coal.

Although it is clear that large quantities of power could not be delivered by battery transmission, it is conceivable that a tramway company might be able to maintain 5 h. p. for a customer at a cost not greatly exceeding that of a small steam engine. Mr. Kapp investigated this case. Two batteries of 2½ tons weight each would cost £340, and to this must be added £150 for the motor and and gear. Taking the cost of transit at slow speed at 3d. per car mile, and labor for unloading at 2s. a day, the total annual cost would be £210 a year, or £42 a horse power. Thus even under these favorable circumstances battery transmission is not more favorable than a wasteful local steam engine. If, instead of the batteries, an over head wire were used to transmit the energy, a notable saving would be effected in the first cost. An overhead wire to transmit 5 h. p. could be erected for £130 a mile. An underground wire, however, would be more expensive than batteries, costing £670 a mile. The cost of transmitting 5 h. p. by the different methods mentioned is given in Table II.:

TABLE II.—TRANSMISSION FOR FIVE HORSE POWER.

Distance of transmission in miles.	Actual cost per horse power delivered, if the transmission is.		
	By batteries.	Direct.	
		Overhead.	Underground.
	£	£	£
1	36.1	22.8	33.6
2	37.6	25.6	47.2
3	39.1	28	60
4	40.6	30.6	74
5	42.1	33	87

Mr. Kapp has been fortunate in gaining some very valuable particulars of actual cost in the working of electric battery tramways in Birmingham, Barking road, London, and in Philadelphia. From the latter it appears that a car weighing 10 tons requires at times a power of 17 h. p., and a mean expenditure of 5.6 h. p. At Barking it has been proved, after a long experience, that six cars require an aggregate of 40 brake h. p. hours for each hour they are running, and the accounts show that each brake h. p. at the motor spindle costs £65 per annum, or 50 per cent. more than given by the calculation above. Tables III. and IV. give the first cost and working expenses of the Barking road line, and show that the haulage expenses are about 8d. a mile, or 3d. more than for horseflesh.

Already conductors are laid over a large area of London, and persons requiring power in moderate amount can be supplied at once, if they choose to pay the price asked. At the recognized charge of 7d. per Board of Trade unit, one brake horse power will cost £75 per annum of 3,000 hours, a price which is practically prohibitive for most purposes. It is only when steam and gas engines are forbidden, or where the power required is both light and intermittent, that such terms could be paid. Even at

* From *Engineering*, London.

the modified price of 4d. a unit the annual cost of a horse power would be £44.

TABLE III.—COST OF BARKING ROAD INSTALLATION.

	£	s.	d.
Engine shed and foundations	210	11	0
Steam plant (two 40 h. p. undertype)	1,767	5	0
Charging dynamos (two 50 K. W.)	1,000	0	0
Shafting and belting	184	0	0
Switchboard and instruments	30	0	0
Car shed and charging appliances	282	0	0
Twelve sets of batteries (1.200 cells)	1,776	0	0
Six cars fitted :			
Gearing ... 24			
Switches, cables ... 43			
Motor ... 90			
157	942	0	0
Total	6,191	16	0

TABLE IV.—RUNNING EXPENSES, BARKING ROAD TRAMWAY, 100,844 CAR MILES PER ANNUM.

	£	s.	d.	Pence per car mile.
Wages at depot	677	6	0	1.612
Drivers	601	14	1	1.432
Fuel	433	19	9	1.033
Oil, grease, acid	64	10	0	.153
Depreciation and repairs:				
Steam plant, 5 per cent	88	7	3	.213
Shed, 2½ per cent	5	5	3	.012
Shafting and belting, 2½ per cent	4	12	0	.011
Dynamos, 5 per cent	50	0	0	.018
Switches, cables, 5 per cent	28	10	0	.067
Gearing, 50 per cent	72	0	0	.171
Batteries, 66 per cent	1,184	0	0	2.818
Motors, 33 per cent	180	0	0	.428
Total	3,390	4	4	8.068

On the Heating of Bright, Freely Extended, Copper Wires by the Current.*

BY U. BARBIERI.

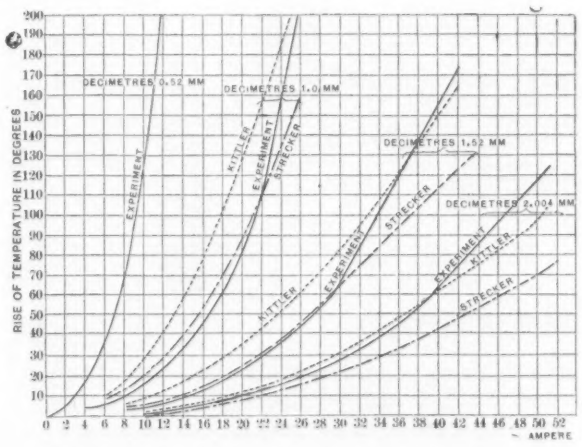
In order to calculate the rise of temperature of bright wires (extended horizontally) by the current there are various formulæ, those of Kittler, Uppenborn, Strecker, Sabine, etc. These formulæ give very different results, as the constants by which the ratio $\frac{i^2}{r^3}$ is multiplied in the formulæ vary between 0.1 (Sabine) and 0.03 (Strecker). The object of the present inquiry is to ascertain which of the existing formulæ express such rises of temperature with an accuracy sufficient for practical purposes, and, indeed, if any of them can be regarded as sufficient for all cases.

COURSE OF THE INVESTIGATION.

A wire about seven metres in length is fixed securely at one end, and at the other it is carried over a pulley, the axle of which carries round with it, synchronously, a mirror. At the exact distance of one and one-half metres from this rotating axle there is a scale, suspended vertically, which allows the values to be read off directly by means of a telescope.

At the end which passes over the pulley the wire is kept stretched by means of a weight equal to one-tenth of the breaking strain as calculated from the section, etc. The temperature of the room is shown by three thermometers hanging near the wire.

Each wire was first overheated by a strong current in order that bends and other irregularities might be removed as far as possible. In the experiments the deflection of the mirror occasioned by the heating effect was observed. We calculated then from the radius of the pulley and the distance of the scale the increase of length from which the rise of temperature is derived, by the aid of the coefficient of expansion of copper.



CURVES OF RISE OF TEMPERATURE IN COPPER WIRES.

In order to be independent of the possible difference of materials as regards the coefficient of expansion, direct experiments on the thermic elongation of the description of copper used were instituted and rapid changes of temperature were effected by heating the room and then opening the windows (in winter).

RESULTS.

Four copper wires (obtained from the firm Küstermann here) of respectively 0.5, 1, 1.5 and 2 millimetres diameter were examined. The results are given in the accompanying table, and are represented by the curves. It appears from the numbers that the so-called constant varies not only with the diameter, but that in one and the same wire it is not uniform with currents of different strengths.

* From the *Elektrotechnische Zeitschrift*.

If we take the mean values for the coefficient of the term $\frac{i^2}{r^3}$ there result, if we merely consider increases of temperature up to 100, the following numbers for the several diameters:

Diameters. Millimetres.	Coefficients.
0.5	0.018
1.0	0.024
1.5	0.030
2.0	0.036

The formulæ of Kittler and Strecker are shown in the table of curves. We see that for thinner wires (1.0 and 1½) the former gives too high values between 0 and 100 degrees; for a 2-millimetre wire the theory agrees approximately with the experiments; it agrees closely with the increases of temperature which were observed in the 1 to 1½ millimetre wires. Both would probably show too slight rises of temperature, both for greater diameters and for higher strengths of current.

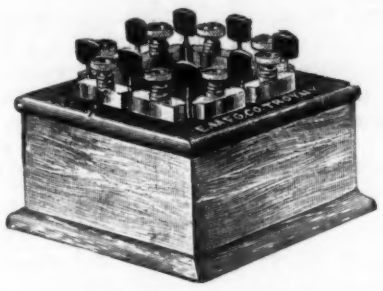


FIG. 50.—STANDARD 100,000 OHM RESISTANCE BOX.

Diameter of wire.	Strength of current.	Rise of temperature.	Constant.
0.52 mm.	3.2	10	0.0151
"	4.5	20	0.0254
"	6.2	40	0.0167
"	8.4	80	0.0176
"	9.8	120	0.0194
"	10.9	160	0.621
"	11.9	200	0.022
1 mm.	7.7	10	0.0206
"	10.7	20	0.0215
"	14.5	40	0.0228
"	18.6	80	0.027
"	21 3	120	0.033
"	23.5	160	0.036
"	25.7	200	0.0375
1.52 mm.	13.5	10	0.0234
"	18.3	20	0.0273
"	24.7	40	0.0275
"	32	80	0.0325
"	36.4	120	0.0371
"	39.5	150	0.0405
"	42	176	0.0420
2.004 mm.	14.5	5	0 024
"	19	10	0.027
"	25.2	20	0.031
"	33.7	40	0.036
"	39	60	0 039
"	43	80	0.043
"	47	100	0.046
"	51	120	0.047

Since the conclusion of this investigation comprehensive results on the question have been published by Kennelly. Still the foregoing communication will not appear superfluous, because another direct method was employed, which renders the results independent of the knowledge of the galvanic coefficient of temperature of the single wires.

Kennelly's figures refer to thicker wires from two millimetres upward, while here thinner wires from one-half to two millimetres have been considered, so that the two investigations are complementary to each other. The observations on wires of two millimetres in thickness, which have been carried out in both, allow a comparison of the results, which shows a satisfactory agreement as it appears from the subjoined conspectus.

RISE OF TEMPERATURE.

	5° C.	10° C.	20° C.	40° C.	80° C.
STRENGTH OF CURRENT.					
Kennelly	12	18	25	35	47
Barberie	14.5	19	25.2	33.7	43

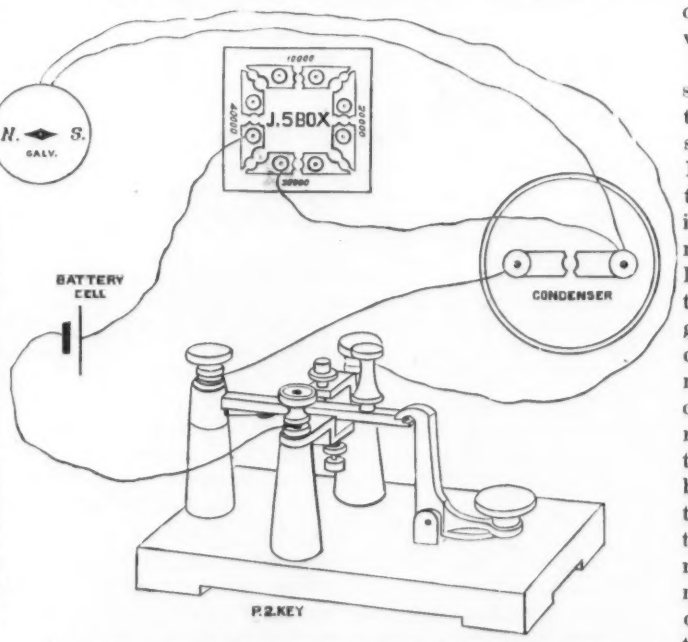


FIG. 51.—DIAGRAM OF CONNECTIONS FOR INSULATION TESTS.

The Construction and Use of Electrical Testing Apparatus.

BY CHARLES P. FREY.

XIII.

Insulation Tests, Retention of Charge.—In order to test the condition of a condenser, and discover if any impairment of its insulation has taken place, a set of apparatus consisting of an adjustable megohm or 1-10 megohm resistance box (Fig. 50), one or more cells of battery and an improved discharge key are employed. The best discharge key in use at present is the one illustrated by Fig. 52, which, as described by its inventor, Mr. R. J. Pratt—

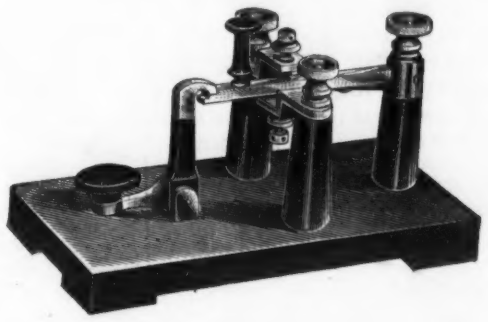


FIG. 52.—IMPROVED DISCHARGE KEY.

"Consists primarily of a solid lever, hinged at one end and playing between two adjustable contacts attached to two insulated terminals. A finger trigger is hinged to the base of the instrument, and this trigger carries a brass hook which overlaps steps cut in the extremity of the brass lever. If by means of the knob the lever be pushed down against the lower contact, the hook of the trigger will catch upon the upper surface of the lever. The key is now in the position to charge. If in this position the trigger be depressed, the hook will be carried forward a little, allowing the lever to rise by means of its spring until the first step is against the hook, thus insulating the lever from both contacts; and this is the position shown in the cut. If now the trigger be pressed so as to overcome the resistance of a second spring, the lever will spring up against the top contact, causing a discharge."

The chief advantage this key has over those invented by Kempe and Webb is that it combines the best features of both of these instruments. Two hands are necessary to operate Webb's key, and two finger triggers are used on Kempe's. The advantageous features of the key recommended by the writer may seem to be but trivial, but when we take into consideration that testing outfits are already assuming formidable proportions, and are becoming more and more intricate, a key which is constructed in a manner which prevents the possibility of premature discharge or incorrect manipulation is unquestionably superior to one which permits these hindrances to rapid work.

When the apparatus described has been connected as shown in Fig. 51, then by depressing the lever on the key the condenser will be charged. Charge for a number of seconds, and at once discharge by pressing on the trigger. Note the exact number of scale divisions through which the spot of light from the galvanometer mirror moves. If it swings off the scale, reduce the current by increasing the resistance, and repeat the operation. When the exact length of swing has been ascertained, recharge, and noting the time, let the lever of the key up one step by pressing gently on the trigger. This cuts off the battery, but the condenser cannot discharge through the galvanometer until the key is entirely up. Allow the condenser to remain charged for five or ten minutes, noting the time, then depress the trigger and note the deflection produced. If the deflection is as great as before, the condenser has lost none of its charge; that is, there has been no leakage from one of its set off plates through the dielectric to the other. This, however, is rarely the case, although the reduction in capacity in five minutes should be barely perceptible, if the condenser is clean and dry and the atmosphere is not too moist. When there is a decrease in the deflection of the galvanometer needle, and a practically constant battery has been employed, the amount of loss can be directly calculated from the respective deflections for the interval of time which has elapsed.

It must, however, be remembered, when considerable deflections are to be measured by an astatic galvanometer, that such a galvanometer must first be graduated empirically by securing it and its scale or reading telescope in a fixed position, and calibrating the deflections by using currents of known quantity. This, when sufficient resistance is obtainable, and a standard cell is provided, is not difficult. From the deflections so obtained a table may be constructed referring to the arbitrary divisions, if on the scale. With sufficient data of this kind, intermediate readings or interpolations can be quickly had.

The retention of charge of a cable can be tested with the outfit described. It is also evident that the capacity of two condensers may be compared therewith, but better results will be secured if the "mull" method explained in a preceding article is employed.

Alloys for Resistance Coils.*

BY DR. K. FEUSSNER AND DR. ST. LINDECK.

As is well known, for the purpose of electrical resistance coils for exact measurements it is best to use alloys and not pure metals, owing to the large increase of resistance that takes place in the latter when their temperature is raised. For pure metals this increase generally amounts to .004 for each degree Cent., while for most alloys it is considerably less; in German silver, for instance, an alloy of four of copper, two of zinc and one of nickel, it is only about one-tenth as large.

A series of tests have been conducted by the authors on various materials with the view of determining their applicability for this object. Some of the results for eight different wires are given in the annexed table. As will be seen, this contains first a statement of the constitution of the various wires (in the cases of the first six as determined from analysis at the government laboratory, for the other two from the manufacturers' certificates), the specific resistance in microhms per cubic centimetre, and the temperature coefficient.

Column I. gives figures for the German silver ordinarily used for resistance coils by Messrs. Siemens and Halske. Under various conditions this wire shows remarkable changes in its resistance, and such changes tend almost always toward an increase. When the wire is coiled its resistance increases, and the smaller the coil the greater the increase. Where the diameter of the coil is ten times the diameter of the wire, the increase amounts to .01 of the original value. After coiling, and when the layers are undisturbed, the resistance still goes on increasing, but at a continually diminishing rate. During the first eight days after winding, the increase amounted to .0003. Warming the wire for the first time to a temperature of 40 degrees Cent. generally increases its resistance by .0004 of its value. After a long-continued heating to a high temperature the effect of a subsequent heating became less noticeable, but never entirely disappeared. Generally the resistance of such wires never becomes quite constant, the variation sometimes amounting to .0001 in a few days.

	I. German silver.	II. III. Obermaier's nickelin. A diam. 1.0 mm.	II. III. Obermaier's nickelin. B diam. 0.1 mm.	IV. Rheotan.	V. VI. Patent nickel. A diam. 0.6 mm.	V. VI. Patent nickel. B diam. 1.0 mm.	VII. Manganese copper.	VIII. Nickel manganese copper.
Copper....	60.10	61.63	54.57	53.38	74.41	74.71	70	73
Zinc.....	25.57	19.67	20.44	16.89	0.23	0.52	..	..
Tin.....	..	..	..	..	..	Trace.	..	..
Nickel....	14.03	18.46	24.48	25.31	25.10	25.14	..	3
Iron.....	0.30	0.24	0.64	4.46	0.42	0.70	..	..
Cobalt.....	Trace.	0.19	..	..	Trace.	Trace.	..	..
Manganese.....	Trace.	0.18	0.27	0.37	0.13	0.17	30	24
	99.86	100.37	100.40	100.31	100.29	100.24		
Special resistance.	30.0	33.2	44.8	52.5	34.2	32.8	100.6	47.7
Temp. coefficient.	0.00036	0.00030	0.00033	0.00041	0.00019	0.00021	0.00004	-0.00003

For exact measurements a wire of such properties is very unsuitable. What is wanted is an alloy, as far as possible free from this variability, and also possessed of a low temperature coefficient. First nickelin, which has lately often been used, was tested. The results obtained from two varieties of this wire, as made by Herr Obermaier, of Nuremburg, are given in columns II. and III. Chemical analysis shows that they are virtually German silver with somewhat increased proportions of nickel, and that they can therefore hardly justify their claim to a special name. Their resistance is, however, higher, and their temperature coefficient lower, than that of ordinary German silver. Tested for constancy of resistance, they showed an improvement on German silver, though the above-mentioned faults still existed.

In the fourth column are given the results obtained with Dr. Geitner's "rheotan," a wire lately brought out specially for resistance coils. Chemically it differs from the nickelin of column III. only in the replacement of four per cent. of zinc with iron. Its high temperature coefficient makes it less suitable for resistance coils than nickelin. At the same time, from its chemical composition, it can hardly be expected to give much better results with regard to constancy, but, owing to our not having any wire of convenient thickness at hand, we cannot give the results of experiments on this point.

To explain the continuous alteration in resistance of the above wires, it must be pointed out that the operations of casting, drawing, etc., always produce a tendency toward a crystalline structure. We conjectured, therefore, that the variability of the resistance depended upon the presence of zinc, which is easily crystallizable, and we accordingly looked for an alloy of nickel and copper or nickel and silver only. While still thus engaged, we obtained from Messrs. Siemens and Halske a resistance coil with the extremely low temperature coefficient of .00017. By the courtesy of these gentlemen we learned that the wire of which it was made was obtained from Messrs. Basse and Selve, of Altena, and we received samples thereof for testing bearing the label "patent nickel." Columns V. and VI. give the results obtained for wires of two different thicknesses, the analysis showing that no metals other than copper and nickel were present to any appreciable extent. Tests were carried out as to the constancy of their resistance, exactly as was done with the German silver and nickelin wires. On being wound, the resistance rose as in the former case, though to only half the extent, and on being left to itself for a few days the resistance of the coil returned to its original value, which never happened with the others. On being heated, the resistance fell, but a coil which had once been heated for some hours to 150 degrees showed no permanent alterations after subsequent heatings to 100 degrees, and is at present perfectly constant.

On the general behavior of wires with regard to changes in their resistance we have arrived at the following conclusion: By all mechanical operations, including the winding of coils, the substance of wire is subjected to stresses, which harden it and raise its electrical resistance. By a subsequent heating the former condition may be gradually restored, as in the case of annealing. Moreover, in the case of German silver and nickelin wires a gradual change toward the crystalline state or a crystallizing out of certain constituents is always going on, and through this the electrical resistance slowly increases. Under the influence of heat this change goes on more rapidly. In alloys of nickel and copper, which are free from zinc, this tendency to change to the crystalline state does not exist, and, consequently, wires of this sort, after being heated to a certain temperature, possess a definite fixed resistance for any temperature below this.

So far as our observations, therefore, go, patent nickel is exceedingly well adapted for the construction of exact resistance coils. Its extremely low temperature coefficient is an additional advantage.

We also devoted attention to the manganese alloys lately brought out by the Isabellen factory near Dillenburg, particularly to those varieties which, according to Weston, possess a negative temperature coefficient. For the purposes of our examination we obtained pigs of alloy from the factory, and by means of a saw cut them into strips, which were then drawn into wire. The metal is very tough, and draws well, but sawing it is very difficult. Manganese copper (column VII. in the table) is steel-gray in color, nickel manganese copper (column VIII.) being pale rose. Our chemical analyses of the two are not yet completed, and we, therefore, give the manufacturers' figures for their constitution. The specific resistances and temperature coefficients given can also only be regarded as preliminary. It, however, appears that the temperature coefficients are in both cases very small, while that of the second (column VIII.) is undoubtedly negative. Moreover, the extraordinarily high specific resistance of manganese copper is worthy of notice.

We have, therefore, to distinctly assert that alloys are to be found whose resistance decreases with an increase of temperature. It is obvious that these materials are of great importance in the manufacture of resistance coils, especially if by a combination of such materials a wire can be produced with a zero temperature coefficient. This and other interesting points we hope to be able to clear up on a future occasion.

*From the *Zeitschrift für Instrument Kunde.*

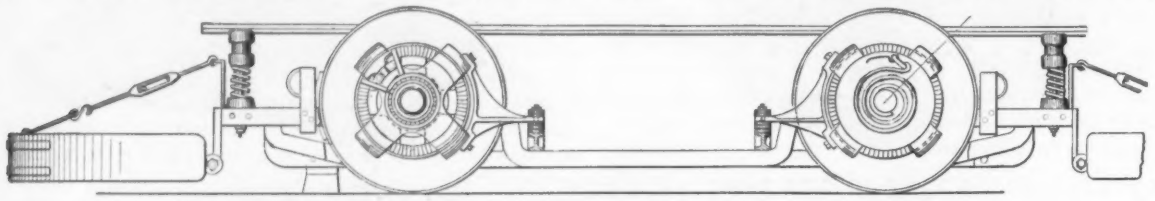


FIG. 1.—SIDE VIEW OF TRUCK EQUIPPED WITH DAHL MOTORS.

Dahl's Slow Speed Railway Motor.

Every operator of an electric street railway has found that one of the weakest points in the system is the gearing which in all commercial roads now in operation is necessary because of the high speeds at which the motors must be run in order to secure the best results from an economical standpoint. Any motor which is designed to be placed directly upon the car axle without any gearing whatever will therefore be of interest to all street railway managers. The two illustrations on this page show a portion of the details of a motor, the invention of Mr. Olaf Dahl, of Allegheny City, Pa., the armature of which is mounted directly upon the car axle.

In this motor an armature of the ring type of large diameter is attached to a non-magnetic spider, which is placed on a shaft or on the car axle, and is free to revolve about it. Attached to this at one end is one-half of a friction clutch, the other side of which is attached to the axle by means of a coiled spring.

The field magnet and pole-pieces of this motor are also somewhat peculiar. Placed on each side of the web of the spider are two magnetic spools and cores, through the latter of which the hub of the spider is free to revolve. Consequent poles are formed by these magnets on the interior and exterior of the armature, alternating in position, those magnets on the outside being brought together and held in position with dowel pins, and a yoke being bolted rigidly to them. This yoke is fastened to the frame or truck to keep the field magnets from revolving. The whole motor will be protected from dust and other foreign substance by a brass case neatly arranged for accessibility. All fuses, connections and brushes are at the top of the motor, and are accessible to the operator when he has opened a trap door in the car and one of the slides in the casing.

The clutch, which is one of the novel features of the motor, is composed of sheet iron discs, each alternate one being fastened at its centre or periphery. Those fastened at the centre are attached to the end of the spider of the armature. Those fastened at the periphery are joined to a spring, as before mentioned. Rigid action is secured by pressing the sheets together by springs interposed in such a manner that at a predetermined pull on the clutch it slips and allows the armature to revolve faster than the axle. A very important matter in so compact a motor is lubrication. This has been amply provided for. The armature is so constructed that each individual section can be replaced without disturbing the others, should it be needed.

By the use of the clutch mentioned it is claimed that it will be impossible to overload the motor beyond a predetermined point.

The armature may be kept running continuously, thereby gaining whatever advantages such a method of operation may possess. The construction of the motor is such that it is practically ironclad, with no outside leakage of magnetism.

Mitis iron will be used for magnet cores, and the clutch will be composed of 40 discs of iron. The weight of a motor rated at 15 h. p. is 1,690 pounds.

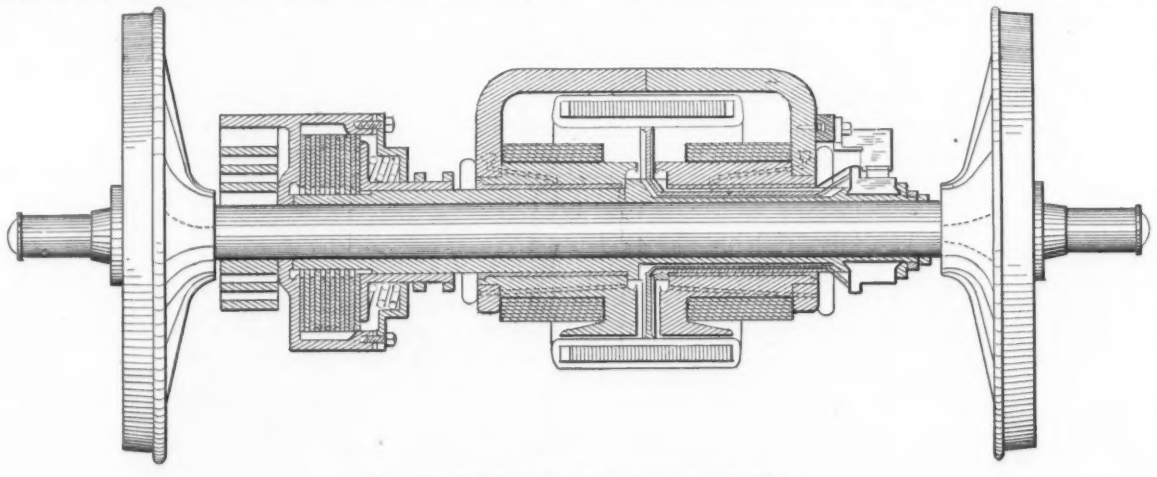


FIG. 2.—SECTION OF DAHL MOTOR.

Electric Light in the Holy Land.

A decided sensation has been caused in Jerusalem, says the London *Electrical Engineer*, by the introduction of electric light into a new and flourishing flour mill lately started there. The building in which the light has been introduced is near to the supposed site of Calvary and close to the Damascus Gate. It need hardly be said that the Arabs and Jews are much puzzled to account for a light in a lamp in which there is no oil, and that up to the present time, while gazing with wonder, they have been keeping at a respectful distance.

European Telegraph Statistics.

In its review of the past year, the *Journal Télégraphique* gives the following figures: According to the latest statistics, the European telegraph administrations now place 353,400 miles of line and 1,023,000 miles of wire at the disposal of the public, an increase respectively of 4.6 per cent. and 3.1 per cent. upon previous returns. The increase in the number of telegraph offices has been very

marked of late. In the seventh edition of the "Nomenclature des Bureaux," which appeared in 1887, 60,000 names were given, while the eighth edition contains 75,000 names, or 25 per cent. more. The number of telegrams transmitted also continues to increase. Last year 200,000,000 messages were dispatched in Europe, of which 45,000,000, or 22.5 per cent., were international.

Financial Intelligence.

THE ELECTRICAL STOCK MARKET.

The Financial Situation.—The condition of monetary affairs in London is having its effect in this country. English investors have been more chary since the panic than for years past. Some of the most excellent investments that have been offered in London have been forced to go to allotment, or in other words, to be taken up by the vendors. A very important banking scheme, backed by some of the most influential men of London, was forced to go to allotment, and of the £200,000 that it was expected the public would take, all that could be raised was £16,000.

Capital in England, outside of London, seems to be more active. There is no good reason for investors in this country following the lead of London's inactivity. Many exceptionally fine investments have been offered since the panic in the shape of investment securities, some of which have sold rapidly and others have not. Especially successful of this class have been the H. B. Claflin Company and the Thurber Whyland Company stocks. Electrical stocks, all things considered, have had a strong market, and have been specially favored since the panic. Railroad stocks, with the exception of a few spurts which have been manipulated, have found a very poor market.

Westinghouse.—It is understood that the time for the placement of the preferred shares of the Westinghouse Company has been extended. This fact, of course, has had the effect of weakening the stock slightly. At the rate the common stock is being disposed off and the ready market it finds, there is no prospect of the failure of the company. From statements made at Pittsburgh, the preferred stock is nearly taken, and 15 days more ought to close up the work successfully. Although a good deal of Westinghouse stock has been disposed of in Boston, there is a disposition on the part of some papers there to be unfriendly to the Westinghouse interests. This is uncalledfor.

Thomson-Houston Company.—The statement has been made that during the year this company consumed nearly 2,500,000 pounds of copper wire, and about 450,000 pounds of brass rods and castings. The stock has had a good market all the week and a dividend is expected by many on series C stock.

Thomson Electric Welding Company.—The directors of this company are going to organize immediately the American Projectile Company, with $500,000 capital, to manufacture shells for the army and navy. The Welding company will retain $250,000 worth of the stock for its patents, and the exclusive use of the welding process in the United States. The remaining $250,000 of the stock is offered at par to the stockholders of the Welding company.

Thomson European Welding Company.—A conference of parties interested in the settlement of the company's foreign contracts was held recently. No payments have been made as yet, but it is understood that arrangements have been consummated for a settlement at an early date.

Edison Stock.—This stock has had a good market all the week. The report now comes officially from the directors of the Edison Company denying the rumor concerning the purchase of stock by the Vanderbilt interest.

Phonograph Stock.—The North American Phonograph Company has passed its regular dividend due last month. This was occasioned by the company being prevented from selling a large number of machines on hand because of an injunction placed on that company by the Automatic Phonograph Exhibition Company. This matter should be compromised by the two companies without delay. F. Z. M.

F. Z. Maguire & Co., electrical securities, 18 Wall street, send closing quotations of electric stocks Saturday, March 7, 1891, in New York, Boston and Washington:

Name of Stock.	Par.	Capitalization.	Bid.	Ask'd.
NEW YORK.				
Western Union Telegraph Co	100	86,200,000	80	80⅛
American Telegraph & Cable	100	14,000,000	79¾	80¼
Central and South American	100	5,000,000	145	160
Mexican	100	2,000,000	210	220
Commercial Cable Co	100	7,716,000	106	109
Postal Telegraph Cable	100	5,000,000	39	41
Edison General Electric Co	100	15,000,000	100	104
Consolidated Electric Light	100	1,929,400	....	....
" " deferred	100	2,496,500	....	....
Edison Electric Illuminating Co	100	2,567,800	79	....
United States Electric Light	100	1,500,000	30	....
North American Phonograph	100	6,200,000	....	....
BOSTON.				
Thomson-Houston Electric Co	25	6,000,000	43⅜	44
" " preferred	25	4,000,000	25¼	25¾
" " Series C	10	400,000	12½	13
" " Series D	10	120,000	6¾	7
" International Co	100	1,000,000	....	....
Thomson Welding Co	100	1,000,000	....	....
" European Welding Co	100	1,000,000	55	....
Ft. Wayne Electric Co	25	4,000 000	12⅜	12½
Telephone:				
American Bell	100	12,500,000	193½	194½
Erie	100	4,800,000	47½	...
New England	100	10,304,600	50	....
Mexican	10	1,280,000	80c.	85c.
Tropical American	10	400,000	....	1
Edison Phonograph Doll	10	1,000,000	....	1
WASHINGTON.				
Pennsylvania Telephone	50	750,000	25	....
Chesapeake & Potomac	100	2,650,000	55	65
American Graphophone	10	600,000	7	7⅝
United States Electric Light (Washington)	100	300,000	160	165
Eckington and Soldiers' Home Electric Ry	50	352,000	55	58
Georgetown and Tennallytown	50	200,000	60	63¼

Chicago Quotations.—Col. S. G. Lynch, broker, 153 Monroe street, Chicago, furnishes quotations on telephone and electric light stocks as follows:

Chicago	$230@$245	Cumberland	$60@ $62
Central Union	57@ 58	Wisconsin	118@ 120
Michigan	85@ 86	Bell of Missouri	160@ 165
Great Southern	30@ 32	Iowa Union	20@ 22
Colorado	34@ 36	Missouri and Kansas	54@ 56
Rocky Mountain Bell	40@ 43		

ELECTRIC LIGHT STOCKS.

Chicago Arc Light and Power	$104@$105	Chicago Edison	$140@$150

NEW INCORPORATIONS.

The Citizens' Electric Company has been incorporated at Pueblo, Col., with a capital of $100,000.

The Joplin and Grand Falls (Mo.) Electric Railway Company has been incorporated with a capital stock of $100,000.

The Medina (N. Y.) Electric Company has been incorporated by C. T. Moffett, H. C. Hodgkins and R. J. O'Donnell, with a capital stock of $20,000, to supply the town of Medina with electric lights.

The Jellico (Tenn.) Ice and Electric Light Company has been incorporated by A. Bindewald, Wm. Meyer and J. L. Reed.

The La Grange (Ky.) Electric Light and Power Company, with $15,000 capital stock, has been incorporated, with J. T. Risley, president, and D. C. McDowell, secretary.

The Salem (Va.) Electric Company, with $100,000 capital stock, has been formed to establish an electric light plant. The same company probably has in view the establishment of an electric street railway.

The Electrical Expert Company has been incorporated at Chicago, with a capital stock of $25,000, for the manufacture of electrical and other machinery, and to engage in electric engineering. Incorporators, H. M. Wolf, F. G. O'Connell and A. A. Bliss.

The Pacific Telephone Attachment and Record Company, of San Francisco, Cal., has been incorporated. The directors are: Henry Wadsworth, William B. Wilshire, H. G. Phillips, H. F. Dugan, L. L. Bromwell. Capital stock, $100,000, all of which has been subscribed.

The Holson Electric Harness and Supply Company has been incorporated at Chicago, with a capital stock of $250,000 for the manufacture of electrical devices and apparatus for harness and carriages. Incorporators, Albert B. Holson, S. W. Gehr, Robert Lindblom and J. J. Wright.

The Waco (Tex.) Electric Railway and Light Company, with a capital stock of $300,000, has been organized by W. J. Hobson, of St. Joseph, Mo.; James Orr, of Terrell, Tex., and others, and will erect an electric light plant, and will sink artesian wells in order to utilize the water pressure for power.

The Continental Electric Construction Company has been incorporated at Chicago with a capital stock of $250,000, to build, equip and operate street railways, electric light, power and heating plants, and to do a general electric manufacturing business; incorporators, William F. Orrell, Oren I. Wheat and Leslie C. Orrell.

The Spokane and University Heights Street Railway Company, of Spokane Falls, Wash., has been incorporated, and will construct and equip six miles of electrical road. The officers of the corporation are: Allan V. Garratt, president and general manager; Robert Abernethy, vice-president, and L. B. Cornell, secretary.

The Gouhegan Electric Light and Power Company, of Milford, N. H., has been incorporated with a capital of $30,000. The officers are: Theodore P. Dresser, president; W. A. Clark, Jr., treasurer, and George A. Beatty, secretary. The directors are T. P. Dresser, G. A. Beatty, C. E. Pendleton and W. A. Clark, Jr., and C. E. Pendleton is general superintendent.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-177 TIMES BUILDING, NEW YORK, March 9, 1891.

The Munsie-Coles Subway Company has opened offices at 116 West Twenty-third street, where a complete exhibit of its specialties are shown.

Woodbridge and Turner, electrical engineers and contractors, formerly at 74 Cortlandt street, New York City, have removed their office to 47 Times building.

Meeting of the Electric Club.—The regular meeting of the club to nominate officers for the year beginning May 1, 1891, will be held at the club house, on Twenty-second street, Tuesday evening, March 17, at 8 o'clock.

Brooklyn Institute Lecture.—Mr. E. N. Cutler, general manager of the Elektron Manufacturing Company, will deliver a lecture on March 20, in the Brooklyn Y. M. C. A. building, entitled "Electric Motors and Their Construction."

The San Antonio (Tex.) Street Railway Company has now equipped about 15 miles of electric railway. Sprague and Thomson-Houston motors are used. Mr. A. W. Wise, president of the road, says that the company is thinking of extending the line.

Messrs. Reed and McKibbin, of 32 Liberty street, New York, are receiving bids and preparing specifications for 17 miles of street railway, with 25 cars. They have also a large amount of other work on hand, and will soon move to larger and more commodious quarters.

Universal Arc Lamp.—The result of the successful exhibition of this lamp at Providence has resulted in the company being almost swamped with orders, and only proves that the public appreciate a good article when they see it. It also proves the entire success of the use of arc lamps on incandescent direct circuits.

The Fifty-fifth Meeting of the American Institute of Electrical Engineers will be held at 12 West Thirty-first street, on Tuesday evening, March 17, when a paper will be read by Mr. J. J. Carty, electrician of the Metropolitan Telephone and Telegraph Company, on "Inductive Disturbances in Telephone Circuits."

The Pierce Steam Heating Company has opened a large and well-appointed exhibit room and warehouse at 92 Centre street, New York, where the trade and others contemplating the introduction of improved heating apparatus will find it to their interest to call. Mr. J. A. Goodrich will be the New York manager, and Mr. F. H. Lovejoy, formerly with the Wainwright Company, of Massachusetts, will act as general agent.

The Smith & Vaile Company, of Dayton, O., builders of steam pumping machinery, is to be congratulated on having secured the services of Mr. J. M. Duncan as manager of its New York office. Mr. Duncan is well known in the East and also in the West, where for several years he has been actively engaged in pushing the sale of the well-known Rice engine. Mr. Duncan will be a welcome addition to the steam and power fraternity in the East, and we wish him a full measure of success.

Good Work Appreciated.—The following resolution adopted by the Board of Fire Commissioners of this city has been promulgated: "*Resolved*, That the Board of Fire Commissioners hereby directs the entry in the minutes of its high appreciation of the excellent judgment and tireless energy displayed by Chief of Department Hugh Bonner and by Superintendent of Telegraph J. Elliot Smith in promptly and successfully meeting the serious emergency which arose from the destructive storm of Jan. 25, 1891."

Electric Motors in Court.—A 1-h. p. slow speed Crocker-Wheeler motor was wired up in the United States District Court, Post Office building, in this city, recently, to run a linotype to show its workings in a patent suit. The motor elicited much favorable comment and was carefuliy examined by the judges.

Actions of the Board of Electrical Control.—Mayor Grant with the Board of Electrical Control passed three resolutions of note with regard to wire stringing in the city. No. 1 requires that all housetop lighting and power wires below Canal street, within a block of a subway, be removed within 30 days. A map of the lower part of the city was submitted by Dr. S. S. Wheeler showing where long lines of such wires had been run. These wires, Mr. Wheeler said, were put up without permission. Resolution No. 2 requires the Subway Construction Company to build needed subways in all streets which the Board of Estimate has ordered repaved this year, before the new pavements are laid, and directs the electric light companies to inform the Subway Company within one week where they want subways. Resolution No. 3 authorizes the removal of all poles and wires found in New York between Third and Eighth avenues and Eighth and Fifty-ninth streets, after June 1. Mr. Paul D. Cravath, representing the United States and other companies, wanted certain streets excepted from the resolution, no subways having been provided. He instanced Seventh avenue, from Fourteenth to Forty-second; Fifth avenue below Twenty-third; the east side of Third avenue, from Eighth to Fourteenth street; Clinton place, University place and Ninth street. Ex-Judge William H. Kelly, for the East River Company, added Eighth street west of Third avenue, and Irving place between Fourteenth and Twentieth streets. "You ought to except, also," remarked President Cutler, of the Metropolitan Telegraph and Telephone Company, "our few distributing poles, where the wires come out of the subways." "You don't appear to grasp the meaning of this resolution," said the Mayor. "It is intended to rid the streets of all poles and all overhead wires. Use the house tops." "Sometimes they won't let us do this," Mr. Cutler answered. "Then let them do without the telephones," the Mayor replied.

L. H. H.

NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
Room 28, Hathaway Building, 620 Atlantic Ave.,
BOSTON, March 7, 1891.

Thompsonville, Conn., is to have an Edison electric light plant.

The Belt Line Street Railway Company of Lynn will pay a dividend of five per cent. to stockholders July 1.

The Peabody (Mass.) Electric Light Company has withdrawn its petition for location of poles in that town.

The Corliss Engine Company is receiving some very large orders for its engines, and its business is consequently booming.

Motor Installation.—The Nashua (N. H.) iron foundry is putting in a 25 h. p. motor for running the blast and other machinery.

The Lawrence Gas Company has finally secured permission from the Gas Commissioners to carry lines for electric lighting into Methuen, Mass.

Annual Ball.—The New England Telegraph and Telephone Company's Inspectors hold their annual Ball in Odd Fellows Hall, Boston, April 15.

The Shipman Engine Company has just sold a two h. p. engine to H. M. Mitchell, South Boston, to run a 20-light Kimball dynamo for lighting a restaurant.

E. M. Carhart & Co., of Providence, R. I., are bringing out several specialties, among which are a mast arm which is proving a success; a new carbon holder, a tree insulator, a cable support and various others.

Mr. G. W. Blodgett, of the Boston and Albany Railway, is delivering a course of lectures on "The Application of Electricity to Railway Signals" before the senior electrical students of the Massachusetts Institute of Technology.

Mr. Henry F. Kellogg has been appointed manager of the Light and Power Department of the Eastern Electric Supply and Construction Company, of 65 Oliver street, Boston, and Mr. F. E. Alexander, formerly of the Westinghouse Electric Company, is now with the above company. Mr. Alexander is an old timer and well and favorably known in the electrical world. He will attend to the above company's increasing central station trade.

Biographical Sketch of F. E. Pettingell.—It is a well known fact that the electrical industry is mainly in the hands of young men, as is well shown by the character of those who gather at every convention of the different branches of the industry. Among the many successful ones is Mr. F. E. Pettingell, president of the Pettingell-Andrews Company, of Boston, one of the largest supply houses in the United States. Mr. Pettingell was born on Feb. 18, 1861, and has therefore just passed his thirtieth birthday. He commenced life in the insurance business in Boston, remaining in that line only a short time, after which he "followed the road" as salesman for different interests, traveling extensively. Early in 1884, while representing a large New York house, Mr. Pettingell became impressed with the idea that there was a great future in the electrical field, and decided to direct his energies in that direction. In order to gain knowledge sufficient to be of service in a commercial way, he connected himself with the Salem (Mass.) Electric Lighting Company, Salem being his early home. A few months later, in order to perfect his knowledge, he entered the service of the Consolidated Electric Lighting Company of Portland, Me., and in 1885 offers were made to him by the Edison Electric Company of New York which were so flattering that he resigned and again became a New Yorker. Mr. Pettingell was afterwards connected with the Brilliant Carbon Company of Pittsburgh, doing all the outside work; the Boulton Carbon Company of Cleveland as general sales agent, until the carbon trust was formed, then with the Cleveland Motor Company until he resigned, in 1887, and started an agency and supply business in Boston. At first, like other companies that are now large and successful, Mr. Pettingell only occupied a small office. His abilities, however, were soon recognized, and attracted the attention of Mr. D. A. Andrews, who likewise had directed his attention to the electrical business as a "coming one." Associating together, Messrs. Pettingell and Andrews opened what was then a large store in the supply line at the corner of Franklin and Congress streets. Here their business continued to increase, and soon was so large that new quarters were necessary, and about a year since they removed to 192-202 Summer street, where their extensive supply house occupies many thousand feet of floor space, and where their force has been increased accordingly to supply their extensive trade. A few months since a corporation was formed, and Mr. D. A. Andrews, Jr., and Mr. C. A. Price were made members of the firm. This company was the first to advertise as doing an electric railway supply business, and, besides doing a general supply business, is a large manufacturer, controlling many valuable patents.

C. A. B.

PHILADELPHIA NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
31 CITY BUILDING, PHILADELPHIA, March 7, 1891.

Baltimore, Md.—The Wenstrom Consolidated Dynamo and Motor Company has removed its office from 6 South street to the new factory at Calverton Heights.

Mr. T. L. Townsend, representing the Partrick and Carter Company, will start early in March on his spring trip. He will have many new goods to introduce which are now being manufactured and sold by this house.

The Horn, Brannen and Forsyth Manufacturing Company has recently added many new designs in gas, oil and electric fixtures, and reports brisk business. Three months' work with their entire force is needed to complete the orders now on hand.

Jos. C. Paulus & Co., sole agents for the Chas. Munson Belting Company, have contracted to furnish the Philadelphia Brush Electric Light Company with 130 feet 48-inch 3-ply belt. They also have the contract to equip the entire new oilcloth factory of G. W. Plabon & Co., of Nicetown, with Munson belting.

The Germantown Smelting and Refining Company has purchased from M. R. Muckle, Jr., & Co. a 60 h. p. Standard Westinghouse engine to drive the dynamo for its electrical refinery. This company is making a specialty of electrotyping copper, for which they have a large and increasing demand.

The Thomson-Houston Electric Light Company of this city has made among the recent installations a 150 incandescent light plant for Messrs. Martin, Fuller & Co. at the Philadelphia stock yards, an 800-light plant for the Monmouth Park (N. J.) Association, a 100-light plant for the Mutual Oil Company, at Reno, Pa., and an additional arc plant for Messrs. Yates & Co., Thirteenth and Chestnut streets, Philadelphia.

The Thomson-Houston Motor Company's offices have been transferred from 1,218 Filbert street to the general offices of the company at 509 Arch street, and has been placed in charge of Mr. C. K. Westbrook, manager of the isolated lighting department, where all applications for power appliances can be made. The company has also established a railway department at 509 Arch street, which will be under the general management of Mr. E. D. Mullen.

Messrs. M. R. Muckle, Jr., & Co. have sold to Messrs. Walker & Kepler, local agents for the Edison system, a 25 h. p. standard Westinghouse engine to drive the electric light plant for A. H. Warthman & Co., Thirtieth and Race streets. Also a 10 and 18 × 10 Westinghouse compound engine to the Pennsylvania Railroad Company, which will be used in running the dynamo which charges the storage battery plant at the main office, at the corner of Fourth and Walnut streets.

Harrisonburg, Va.—The Electric Light Company, of which Mr. Wm. E. Groff is superintendent, has just added another 750-light Westinghouse alternating current dynamo to its plant, making the total capacity 1,250 lights. Another dynamo will be added at an early date. The members of the Electric Light Company have just organized a company to put in an electric railroad. Mr. Groff is also superintendent of the railroad company. The capital stock is $50,000, and a road four miles in length will be put in, to be equipped with five cars. W. F. H.

WESTERN NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
465 THE ROOKERY, CHICAGO, March 7, 1891.

Mr. C. F. Dunderdale has been appointed general sales agent for Alexander, Barney & Chapin, of New York City.

Mr. A. B. Gould, proprietor and manager of the Gould American District Telegraph Company, Sioux City, Ia., was a visitor in Chicago last week.

Mr. H. H. Humphrey has accepted the position of Superintendent of the Englewood Electric Light Company, vice Mr. Richard Fergerson, who retires to engage in independent construction work.

Mr. Weare Parsons, formerly associated with the Westinghouse Electric and Manufacturing Company, of Pittsburgh, Pa., has been appointed electrician for the Milwaukee Light and Power Company at Milwaukee, Wis.

Mr. J. E. O. Bennett, of Evanston, has joined the ranks of contractors of electric construction work. The experience gained during his connection with the National Engineering Bureau will be especially valuable in his new work.

Mr. J. M. Duncan, who is so well known in the West as the successful agent for the John T. Noye Manufacturing Company of Buffalo, will shortly remove to New York City. This removal has been made necessary by his new position as manager of the Smith-Vaile Steam Pump Company.

Mr. C. E. Ransler, one of the proprietors of the Independence Electric Light Company, of Independence, Ia., was a visitor in Chicago last week. Through careful management his business has been so largely increased as to render necessary an additional dynamo and engine in the near future.

The Englewood (Ill.) Electric Light Company found it necessary a short time ago to again increase its dynamo capacity. The business has increased so rapidly under the careful management of Mr. Chas. T. Page that in point of size it compares very favorably with that of more pretentious central stations.

World's Fair.—In the report of the committee, advising that the fair be located in Jackson Park, is the following paragraph: "Your committee believes that electrical displays can be presented with better effect, and to the greater satisfaction of the public, in a building designed for electrical exhibits at Jackson Park, than upon the contracted space on the lake front. This view of the matter is shared by Colonel Clowry, chairman of the Committee on Electrical Exhibits, and by other good authorities. Hence the estimates for buildings can be lessened $250,000 in this direction. The director-general estimates over $300,000 for electric plant and lighting on the lake front."

The annual grand ball of the Brotherhood of Electric Mechanics was held Saturday evening, Feb. 21. The various supply and construction companies had attractive exhibits arranged about the hall. The articles shown included dynamos, motors, lamps, storage batteries, wire, Geissler tubes, annunciators, bells, etc. The Brotherhood of Electric Mechanics has been established in Chicago seven months, and it is being introduced in other cities. Its objects are mutual benefit and the maintenance of a high standard among electrical engineers. C. B. Quealy is the president.

The World's Fair Bureau of Electricity has just been formally organized by the appointment of Mr. J. Allan Hornsby, of Chicago, as secretary of the department under Prof. Barrett. Mr. Hornsby will be located in the Rand-McNally building, and the executive control of all matters pertaining to the electrical section will be vested in him, under the direction of the department chief, Prof. Barrett. When seen by the representative of THE ELECTRICAL WORLD, Mr. Hornsby outlined his course of action as follows: "I shall begin work immediately upon being assigned permanent quarters, and my endeavors will be directed first toward arousing the interest and securing the co-operation of the foreign electrical companies and individuals. Our own countrymen are so deeply concerned in making a superb exhibition, and their interest is so thoroughly aroused, that a large portion of the work of the department is already disposed of. We propose to make the electrical department the grandest of all the sections. At the time of his appointment Mr. Hornsby occupied a position on the editorial staff of the Chicago *Evening Post*.

Electric Club Meeting.—The regular meeting of the Chicago Electric Club occurred Monday, March 2, 1891. After the completion of routine business the following letter was read by Mr. B. E. Sunny:

F. G. Beach, Esq., President Chicago Electric Club.

I have been asked by the Construction Department of the World's Columbian Exposition to appoint for service in that department an electrician competent to undertake an advisory duty on the staff of Chief of Construction of the Exposition. This man will be assigned to duty in the office of the architect. The salary of the electrician has been placed at $2,000 per annum. Recognizing the prominence of the club and the efficient aid I have received from it and its members, I desire to, in a small way, reciprocate by asking that the club at its meeting this evening agree upon some names of electricians, say three or five, from which I can select this officer of the World's Fair. I shall take pleasure in giving precedence to the names the club shall submit. J. P. BARRETT.

The action taken by the club was embodied in the following communication, directed to Prof. Barrett and signed by President Beach and Acting Secretary F. W. Horne:

Prof. J. P. Barrett, Chief of Electricians, World's Fair.

DEAR SIR: I have the honor to report that at a regular meeting of the Chicago Electric Club, held Monday, March 2, 1891, your communication requesting the nomination of three or five electricians from whom to select an electrician to act in an advisory capacity in the office of the Chief of Construction was read and the following nominations were unanimously made: F. Sargent, George Cutter, F. H. Soden, T. G. Grier and George H. Bliss. The club desires to thank you for your courtesy in asking its co-operation in this matter. Yours respectfully,

F. W. HORNE, Acting Secretary. F. G. BEACH, President. H. C. E.

SOUTHERN NOTES.

NORFOLK, Va., March 7, 1891.

Norfolk, Va.—A telephone line is to be established between Norfolk and Newport News.

Cuero, Texas.—It is stated that G. Jaeger will probably establish an electric light plant, to cost $15,000.

Marshall, Tex.—The city council has accepted a proposition to put in 100 electric lights and maintain them for three years.

Bryan, Tex.—Parties are making an effort to organize a company for the purpose of constructing an electric street railway.

Newport News, Va.—The electric light plant of the Newport News Electric Light Company is shortly to be increased in capacity.

Shelbyville, Tenn.—The Tennessee Legislature has under consideration a bill authorizing the establishment of an electric light plant.

Nashville, Tenn.—The Capital Electric Light Company is said to be considering the feasibility of adding a 1,000 h. p. engine to its electric light plant.

Chester, S. C.—Paul Hemphill and others have submitted a proposition to the city council looking to the establishment of an electric light plant.

Roanoke, Va.—The city council has granted G. S. Colgate and others a franchise to establish an electric light and power plant, to cost $100,000.

Houston, Tex.—A 500 h. p. engine and five boilers will shortly be added to the electric light plant of the Citizens' Electric Light and Power Company.

Versailles, Ky.—It is stated that the city council is getting estimates on the cost of electric lights with a view to establishing an electric light plant.

Anderson, S. C.—Mr. W. C. Whitner, manager of the Anderson Electric Light Plant and Water Works, has been engaged by the city council of Newberry, S. C., to make a survey and to furnish estimates of the probable cost of lighting the town with electricity. V. N. B.

WASHINGTON, D. C., March 7, 1891.

Proposals for Electric Light and Gas Fixtures.—The Treasury Department is sending out invitations for sealed bids for manufacturing and placing in position, in complete working order, an equipment of combination electric light and gas fixtures in the new government building at Charlotte, N. C.

The United States Electric Company.—The Commissioners of the District of Columbia several days ago decided to withhold the permit applied for by this company to lay extensions to their underground systems of conduits, aggregating a length of nearly seven miles. The commissioners refused the permit for the present upon the recommendation of Captain Lusk.

A Trial of the Storage Battery.—The trial trip of a storage battery street car over the track of the new G street electric line was made this week, and the experiment is said to have been highly satisfactory to the officials of the road. The car in which the trial trip was made was provided by the Accumulator Company of New York and Philadelphia. This line will be in operation in a few days.

The Hawaiian Cable.—The foreign affairs committee of the House recently reported back the diplomatic and consular appropriation bill, with the recommendation that all the Senate amendments be agreed to with the exception of the amendment providing for a cable between San Francisco and the Hawaiian Islands. Recommendations were unanimously concurred in, the roll being called in order to emphasize the opposition of the House to the Hawaiian cable proposition.

Electric Light Conduits.—In the report upon the District appropriation bill, a compromise was reached in regard to the electric light conduits, and the report provides that, until action is taken by Congress on the report of the board of electrical experts, or until April 1, 1891, the commissioners of the District of Columbia shall not permit the construction of more than five miles of conduits or subways, for electric lighting purposes; or more than five miles of such conduits for telephone service—the law to apply to all permits heretofore or hereafter granted under existing law; such permits, however, not to apply to necessary street or house connections for electric service, nor to change of motive power on street railroads under existing laws. E. A. O.

ENGLISH NOTES.

From our own Correspondent.

LONDON, Feb. 25, 1891.

Atlantic Cable Companies Rivalry.—The Anglo-American and Commercial Cable companies are at the present moment engaged in a sharp struggle for supremacy in the provinces, and the chairman of the Anglo-American at a recent meeting was somewhat severely handled by influential shareholders for not *anticipating* the rival company in the matter of opening offices in important commercial towns in the North, but preferring "to hang onto the tail" of the Commercial company. A few days ago it was advertised that the Commercial company was about to open an office at Pradford; immediately afterward the Anglo-American company announced that it also had engaged offices there, and had made arrangement with the Government for the exclusive use of a direct wire to their cable station.

St. James & Pall Mall Company.—The question whether electricity can be supplied at a profit has been settled, as far as the St. James company is concerned, by the declaration of a five per cent. dividend, the writing off of £1,800 from the machinery account and the carrying forward of over £300. This result, it must be remembered, is by no means a complete answer to the question, since the St. James Company works one of the most compact and favorable districts that can be imagined. So much is this the case that electrical engineers have dubbed it "the cream of the world." The St. James company, which works on the three-wire system, received no less than £13,000 during the year ending Dec. 31, 1890, for sale of current, and has now 30,500 eight c. p. lamps connected to its mains. The total working expenses for the first year were about 60 per cent. of the gross receipts. The company now proposes to increase its capital from £100,000 to £200,000, and to erect a second station in the northern portion of their district.

City & South London Railway.—At the ordinary general meeting of the shareholders of this company on Tuesday (the first such meeting held since the opening of the line) nothing of importance transpired. The chairman's remarks were characterized neither by self-congratulation on the success of the line up to date nor by glowing forecasts with regard to the future He announced, as the report of the directors had already done, that they proposed to increase their rolling stock, make additional sidings and add another engine and dynamo to their generating plant, the latter step being taken in accordance with the requirements of the Board of Trade. In reply to the question of a shareholder, the chairman gave the meeting to understand that although the company was satisfied with the power of their present locomotives they were not so fast as expected, and that the new locomotive would probably be more powerful and faster, and the trains heavier. The chairman also stated that the southern extension to Clapham Common, for which parliamentary powers have long been obtained, would not be carried out as yet, and that the bill now before Parliament for an extension northward was entirely of a defensive character, and that no further expenditure of capital would be risked until the present line was beyond doubt a success. The line has now carried 900,000 passengers. Since its opening, on Dec. 18, 60,000 train miles have been run and £7,500 have been earned, the receipts per train mile being half a crown.

High-Pressure Transmission of Power Experiments at Oerlikon.—As most of your readers doubtless are already aware, it is proposed to transmit some 300 h. p. electricity from Iauffen on the Neckar to the Frankfort Exhibition, a distance of over 100 miles. Nothing blocks the way except the permission and assistance of the German telegraph authorities, who have been petitioned to run the necessary overhead conductors. With a view of satisfying these authorities as to the practicability and safety of the proposed scheme, some interesting experiments were recently carried out at the Oerlikon works in Switzerland. An experimental line about 6½ miles long was employed, the insulation being effected by means of Johnson and Phillips fluid insulators. The arrangements were as follows: A low-pressure alternator driven by an electric motor fed into the primary of a step-up transformer, whose ratio of transformation was 300; the secondary of this transformer was connected to one end of the line, the other end being connected to the primary of the step-down transformer, whose ratio of transformation was the same as that of transformer No. 1. The secondary of the step-down transformer was connected to several banks of lamps, the E. M. F. at the terminals of which was, it will be observed, the same as that at the primary of the first transformer. The net result of the various experiments which were carried out was to satisfy those who witnessed them that the proposed transmission of power at the Frankfort Exhibition was not only practical, but essentially reliable. The only apparatus in any degree novel that was employed was the "oil transformer" of Mr. C. E. L. Brown, of the Oerlikon works. Mr. Brown builds up his transformer in the ordinary way, but incloses the whole in an outer casing filled with oil, with a view of strengthening the insulation between the primary and secondary. In the Frankfort Exhibition transmission apparatus it is proposed, however, not to employ an ordinary alternating current, but what the Oerlikon people call a "rotating current." From the somewhat meager details hitherto published, the idea appears very similar to that originally employed by Mr. Tesla; namely, the transmission by different wires of currents generated by the same machine, but lagging one behind the other in phase.

Deptford.—On Monday last week, after a severe preliminary test of the plant connected with the system, electrical supply was recommenced from the Deptford station at the full pressure of 10,000 volts, the supply having been shut down exactly three months. The exact position of affairs at present is as follows: There are running at Deptford two 1,500-h. p. and two 650-h. p. dynamos. Four complete sets (32 miles in length) of concentric cable have been laid up to London. Two of these run to the Grosvenor Gallery substation, where four 150-h. p. transformers reduce the pressure from 10,000 to 2,500 volts, at which pressure it is transmitted by Siemens or Fowler-Waring concentric sheathed cables to the consumer's transformers, where the pressure is reduced to 100 volts. The London Electric Supply Corporation had in use several miles of overhead conductors, but on recommencing the supply on the 16th they did so by means of underground concentric mains only, and abandoned their overhead system entirely. Two of the Ferranti trunk mains from Deptford run into the Grosvenor Gallery substation, and the four transformers now in use there are connected, two onto one main and two onto the other; and the circuits of these pairs of transformers are kept entirely distinct. At first Mr. Ferranti found that his customers were somewhat shy of being connected up again, but he is hopeful that, if all goes well and no further hitch occurs, this shyness will soon pass away. When the present scheme of Mr. Ferranti is completed in its entirety, which it is expected will be the case within the next three or four months, there will be four transformer substations—at the Grosvenor Gallery, Trafalgar Square, Victoria Station and Blackfriars Bridge. Each of these will be fitted with a

complete set of interlocking switches similar to those employed at important points by our large railway companies to prevent the possibility of mistake. All the transformers stations will be connected together by concentric cables capable of carrying 2,500 h. p. at 2,500 volts, so that the breakdown of the transformers in any one station will not cripple the service of the district served by it. The second pair of Ferranti cables will feed the Trafalgar Square substation, the other two substations, at Blackfriars and Victoria Station, being fed by one or the other of the two pairs of trunk mains at present laid down. The equipment of the stations will be as follows: Grosvenor Gallery, ten 150-h. p. transformers; Trafalgar Square, ten 150-h. p. transformers; Victoria Station, eight 150-h. p, and Blackfriars, six 150-h. p. transformers. It will thus be seen that Mr. Ferranti has made every effort to prevent his entire system being crippled by any single breakdown, and it is sincerely to be hoped that his efforts to prevent further stoppages of the supply will be successful.

Answers to Correspondents.

Questions to be answered in this column must be of general electrical interest, and must be accompanied by real name and address as a guarantee of good faith. No notice will be taken of questions regarding apparatus unless enough details are given to permit a definite answer, and no dynamo or motor designing will be done.

Rapid Alternations—How did Mr. Tesla get the enormously rapid alternations mentioned in his recent paper in THE ELECTRICAL WORLD? J. E. D.

By the use of a special alternating machine having nearly 400 poles, and running at a very high speed. He employed several different constructions for the purpose.

The Beacon Vacuum Pump.—Can you tell me what is being done with the Beacon vacuum pump described in your paper last year, and whether it is meeting with success? ELECTRICAL STUDENT.

The Beacon vacuum pump has done admirable work in the experiments that have been tried with it, but so far as we are aware has not yet been put into active use in a large lamp factory.

Electricity Direct from Coal.—Some time ago I saw a publication concerning the formation of a company in New England for the purpose of developing an invention of a method of obtaining electricity direct from coal. Could you kindly give me the name of the company and let me know if any experiments in this line have proved successful? M. L. N.

We have heard nothing for some time of any company or companies such as the one to which your refer, as would be the case were the invention practical. There have been many schemes for obtaining electricity direct from coal, but none of them as yet has proved commercially successful.

Lamps and Dynamos.—Please answer the following questions: 1. Is there any means of dimming incandescent lamps without proportional loss of current? Would a double filament lamp with a socket to throw the filaments in arc, or in series, accomplish this end well? 2. What is the ratio of efficiency between a good direct current motor and a good Thomson repulsion motor, provided the two are of the same relative size and weight? 3. Wherein does the difficulty lie in getting very small dynamos with drum armatures to build up current? SUBSCRIBER.

1. With alternating current lamps an impedance coil answers the purpose beautifully. With direct current lamps the current consumed if a resistance is interposed is not so great as when the lamp is burning full power, but still the lamp is working very inefficiently. The double filament lamp would be open to the same objection to a somewhat less degree. 2. We cannot state, as the facts regarding the repulsion motor are not known, except in a very indefinite way. It is generally believed to be somewhat less efficient than the direct current motor, although experimentally some very excellent results have been obtained. 3. The magnetic circuit is often very bad, and hence there is very little to build on.

Concerning Induction Coils.—Please answer the following questions concerning induction coils and oblige an amateur subscriber: 1. Have the length and size of the secondary wires anything to do with the quantity and intensity of the induced current, and, if so, how? 2. Would two wires of equal size and length wound over a primary coil have an equal amount of induced current flowing in each, and would that be twice the amount obtained from a single wire when used? 3. Should the primary be an intensity or quantity current? 4. In what proportion is the secondary current to that of the primary? 5. What is the best work on induced currents? O. J. S.

1. The length, that is to say the number of turns, of the secondary wire determines the electromotive force produced; the size of the secondary wire determines the quantity that it is possible to make flow. 2. Yes, very nearly. 3. In an induction coil the primary is usually of low resistance, and hence a current of comparatively low electromotive force and large quantity is used. 4. In an efficient transformer the secondary current is very nearly as much larger than the primary current as the secondary electromotive force is smaller than the primary. In an induction coil the same rule would not hold closely, because the coil is generally inefficient; it would only be true in a rough and approximate way. 5. Fleming's "The Alternate Current Transformer."

News of the Week.

THE TELEGRAPH.

The Direct United States Cable Company, Ltd., of 40 Broadway, New York City, is to remove its offices to 21½ Spruce street. The company will be able by reason of increased facilities to render greatly improved service.

Annual Elections of the (Newark, N. J.) District Telegraph Company.—At the annual meeting of the stockholders of the Newark District Telegraph Company last week the following were elected directors: George W. Hubbell, Thomas T. Kinney, Enos Runyon, Marcus L. Ward, Edward Weston and Frederick T. Fearey. At the last meeting of the directors a five per cent. dividend was declared, payable March 16. The company now employs 30 messengers at the main office, 182 Market street, and keeps them busy delivering circulars, letters and packages at all hours of the day and night. During the recent storm nine special police officers were engaged to watch the places protected by their electric system, and where the wires were broken down. The District Telegraph Company will soon have in operation at the office in this city an entirely new central office burglar alarm system, that is owned exclusively by the company, and which will be introduced into other cities as soon as the work is completed in Newark, N. J. The company has also perfected an extension fire-alarm system for extending fire protection into factories and high buildings, and had it in operation for the past year in a number of places where it has proved most successful. It has the approval of the best experts on fire-alarm telegraph matters. The system will soon be put in operation in the larger cities throughout the country.

THE ELECTRIC LIGHT.

Rushville, Ill.—The electric light plant will be started this week for the first time.

Manchester, Va.—City Engineer Cutshaw is at work preparing plans and estimates for an electric plant, as requested by the municipal electric light committee.

Menominee, Mich—Messrs. Leisen & Henes are about to put in a large private electric light plant by which their brewery, offices and residences will be lighted.

Davenport, Ia.—The Western Electric Company has filed its bonds for $25,000 with the city clerk of Davenport, and will proceed at once to the construction of the plant for lighting the city.

Plymouth, Ind.—Messrs. Stevens and Lauer, managers of the opera house, are endeavoring to make arrangements with the owners of the building to have a large incandescent electric light plant installed.

The Cedartown (Ga.) Land Improvement Company has let the contract for lighting that town by electric light to Messrs. Quackenbush and Miller of the Vernon Light and Power Company at Tallapoosa, Ga.

Vacaville, Cal.—A project is on foot to supply the town with electric lights, and is meeting with hearty support on the part of business men and others. It is stated that enough subscribers have already been secured to make the venture a financial success.

Mount Sterling, Ill.—The Mount Sterling Electric Light and Power Company has elected officers and will push the electric light system rapidly to completion. Washington Brockman is the president, and Clarence Brockman is secretary of the board of directors.

Issue of Bonds.—The city council of Allegheny, Pa., has passed an ordinance authorizing the issue of electric light bonds to the amount of $100,000, to be used toward paying for the illuminating plant recently contracted for by the city and furnished by the Westinghouse Company.

The Vincennes Electric Light and Power Company, of Vincennes, Ind., held its sixth annual meeting recently. The following directors were elected: Hiram A. Foulks, Gerald Reiter, Charles Bierhous, John B. LaPlante, and Royal E. Purcell. The last two gentlemen are new directors, replacing Messrs. J. T. McJimsey and J. D. Lalervix, retired. Mr. Charles Bierhous was elected president, H. W. Frund secretary and general manager and H. A. Foulks treasurer.

THE ELECTRIC RAILWAY.

Clinton, Ia.—The State Electric Street Car Company, of Clinton, has let the contract for the building of an electric street car line in that city, five miles long, to be completed by June 1 next.

The Consolidated Street Railway Company, of Dallas, Tex., will soon extend its lines four or five miles. The company now has 20 miles of road in operation. The city of Dallas appreciates electric traction, having four electric roads in operation there.

Chattanooga, Tenn.—Contracts were awarded last week for the supplies, equipment and system to operate the Chattanooga and North Side Company's electric railroad; also the contract for the North Chattanooga electric line. The contract for the North Side Company's work was awarded by Eugene T. Lynch, New York, who had secured the general contract to furnish the road with the entire equipments. The contract to furnish the motive power has been given to the Thomson-Houston Company, and cars are to be running by May 1.

PERSONALS.

Mr. John Hollins Bowley, once an assistant to Prof. S. F. B. Morse, and who superintended the laying of the first Atlantic cable from the American man-of-war Niagara, died last week at No. 121 Ocean Avenue, Jersey City.

Mr. William C. Miller, electrical superintendent of the Watervliet Turnpike and Railroad Company, gave a lecture last week at Albany (N. Y.) High School, on "Elementary Principles of the Dynamo as Applied to Electric Lighting and Traction."

Mr. H. C. Spaulding, secretary of the Thomson-Van Depoele Electric Mining Company, writes us to correct an impression that has caused him some embarrassment, by connecting his name with a proposed system of underground railways for Boston. Henry C. Spaulding, who is advocating that system, is not Mr. H. C. Spaulding, who is still connected with the Thomson-Houston Electric Company.

Mr. Marsden J. Perry, of Providence, R. I., secured one of the rare books at the sale of Brayton Ives' fine collection in this city last Saturday. The book purchased by Mr. Perry was secured only after a sharp competition and the price paid was $1,150. It was a diminutive copy of Shakespeare's "Venus and Adonis," printed in 1636. There is only one other perfect copy of this little volume in existence, and that is in the British Museum. The copy which now belongs to Mr. Perry was purchased by Mr. Ives at the Barlow sale in this city last year for $1,400.

Industrial and Trade Notes.

Messrs. Pass & Seymour, of Syracuse, N. Y., will soon place upon the market some very handsome colored china electrical fittings.

The Card Electric Company has recently shipped to St. Louis one of its new type six h. p. arc motors. This is a large size for an arc motor.

The "Speed" Wire Stretcher, manufactured by L. E. Wilcox & Co., of Meriden, Conn., is now used by the U. S. Government at Washington, D. C.

Messrs. Brown & Yetter, manufacturing electricians, of St. Paul, Minn., make a specialty of general electrical repairing. They report that they are doing considerable business in their new types of motors.

The Card Electric Company, of Cincinnati, appreciating the value of "Vulcabeston" as an electrical insulator, has recently given the H. W. Johns Manufacturing Company an order for 12 different sizes of "hoods" for its machines.

Messrs. James Schawel & Co., of 29 John street, New York City, are making a specialty of leading-in wires of all sizes for incandescent bulbs, and in addition handle pure platinum in sheet form, furnishing special sizes on short notice.

The Page Belting Company, of Dey street, New York City, in its new store, will have the largest stock of made-up belting in the city. The company will also have a fully equipped shop in the basement, where general repair work will be carried on.

The Pond Engineering Company, of St. Louis, Mo., has issued a pamphlet of its separator for dry steam. The "Pond" separator has long been known to steam users, and is rendering efficient service in many electric light stations throughout the country.

The Eastern Electric Cable Company, of 61 to 65 Hampshire street, Roxbury, Boston, Mass., has issued a new catalogue and price list of the Clark wire and cables, of which this company has control. The book contains beside a number of useful tables and formulæ.

Electric Belt Dressing.—The Buffalo Specialty Manufacturing Company is sending out to dynamo engineers throughout the country a request to send for a sample 10-pound can of belt dressing, which is not to be paid for unless it proves satisfactory. It is claimed that this dressing very greatly increases the life of the leather.

The Electrical Supply Company, of Chicago, always to the front with its complete line of supplies, has issued a supplement to "Catalogue 560" of that company, among the principal additions shown therein being the Dayton arc light cut-out, the Bassett lamp hanger, a line of electric fixtures, Weston instruments, Sunbeam incandescent lamps, etc.

Messrs. Schaeffer & Prudenburg, of 40 John street, New York, the well-known manufacturers of tachometers, have issued pamphlets and price lists of their portable and stationary tachometers for indicating the speed of high speed machinery, and their improved automatic restarting injector, in which is employed a divided or flat nozzle.

Messrs. Chas. A. Schieren & Co. state that the demand for their perforated electric belt is increasing daily, and that they are receiving a great many applications from the trade wishing to have belts of other make perforated. This company installed a 60-inch 3-ply belt this week in the factory of the New York Biscuit Company.

The Law Telephone Company now has the celebrated "Law" battery in use in most of the large telephone stations in the United States. It is also used by bellhangers, especially where good and lasting work is desired. The licensees of the Johnson Electric Service Company, whose heat regulating service requires a good battery, are very large users.

The Prentiss Tool and Supply Company, No. 115 Liberty street, this city, has bought the entire plant of the Love Manufacturing Company, comprising 99 machines, including special tools and fixtures, all in good condition and well adapted for the manufacture of electric and other apparatus. Among them are engine lathes, planers, shapers, milling machines, drills, saws, screw machines, etc.

Messrs. Thompson, Crawford & Co., engineers and contractors, have opened offices at 163 World Building, New York City. The new firm is composed of Walter and George Thompson, well-known electrical engineers, who contracted and built several of the first electric roads established in the United States, and Norman McD. Crawford, lately with the Rochester Electric Railway, and formerly a civil engineer of the Pennsylvania Railroad.

The Gould Packing Company, of East Cambridge, Mass., manufacturers of steam and water packing, has been manufacturing its celebrated packing since 1880 and the appreciation of the public is shown by the daily receipt of large orders from all parts of the country. These goods are always fully warranted and the company shows its confidence in them by offering a thirty days' trial and to pay all expenses for returning goods if not satisfactory, which is evidence that the guarantee means something.

Habirshaw Wire.—The Electrical Supply Company, of Chicago, is supplying the 250,000 feet of Habirshaw wire for the new Leiter building in Chicago. The Electrical Construction Company, which has the wiring contract, says: "As this is one of the finest buildings of its class in Chicago—if not in the world—we wish to make it a model job of wiring. We are so well convinced of the merits of Habirshaw insulation that we are using nothing else for our best work, or in places where none but superior insulation would stand."

The Backus Water Motor Company, of Newark, N. J., has just issued its new catalogue for 1891, containing a description of its patent rotating, as well as exhaust ventilating, fans and the Backus water motor. The patent rotating ceiling and column fans are manufactured in ten styles and nine sizes. This year the company places upon the market for the first time its new nickel-plated clutch, combining with great beauty many features never before attempted, which make it one of the best fans of the kind, allowing the fan to be driven fast or slow, and stopped when desired.

The Page Belting Company, of Concord, N. H., manufactures all grades of leather belting, making specialties of wide main belts, particularly for electric plants, and also of a special grade of single belting, which is called "crown extra." During the past year this company has added to its specialties for electric light work the "acme link" belt, which has been giving very good results, some of them being put into very hard work, and running at an extremely high rate of speed with the best service. This company also reports large and increasing sales of its double flat dynamo belt for driving dynamos.

The Eureka Tempered Copper Company, of North East, Pa., has arranged with the American Railway Equipment Company, of New York and Chicago, to act as general agents for railroads and in all territory west of the Mississippi River. With this addition to its canvassing force and the trade already established, the company will be kept busy during the coming year. This company reports large orders during February from the Edison General Electric Company, the Wenstrom Consolidated Dynamo and Motor Company, the Electro Dynamic Company, the National Electric Manufacturing Company, and the Baxter Electric Motor Company for the new tempered copper. In finished work for central stations the company received upward of 100 orders in the month of February alone.

Messrs. Tucker & Hall, World Building, this city, have received a contract for wiring the Metropolitan Life Insurance Company's building at the corner of Twenty-third street and Madison avenue. The plant will include 4,000 incandescent lights supplied with current from four 650-light U. S. dynamos, and is the first installation in which vulcanoid ducts for electric wires have been called for in the specifications. It is expected that this plant will be one of the most complete in the city. Steam will be furnished by two Watts-Campbell Corliss engines of 125 h. p. each. The switchboard is of polished black marble, mounted in a frame of polished brass. Fourteen double-pole switches of the U. S. pattern will be used and will be mounted directly upon the marble board without intermediate insulating bases.

Business Notice.

Battery Cut-Out, Cheap.—Sensitive, reliable, never requires attention. Gas lighting much improved by its use. Electric Supply Co., of 105 South Warren street, Syracuse, N. Y.

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

U. S. PATENTS ISSUED FEB. 24, 1891.

446,871. Binding Post; Chas. A. Lieb, of New York. Application filed Sept. 19, 1890. The invention consists in a base piece or plug for the binding post comprising a metallic central portion embedded in and rigidly attached to a body or mass of insulating material, and one or more binding screws arranged one above the other, the first one being threaded into the central metallic portion of the base and each succeeding binding screw into the one below it, the several binding screws being interchangeable. (See illustration.)

U. S. PATENTS ISSUED MARCH 3, 1891.

447,291. Electric Dental Motor; Harry H. Blades, of Detroit, Mich., Assignor to the Detroit Motor Company, of same place. Application filed March 23, 1888. In an electric dental motor, the combination of the hand hold, a longitudinally sliding switch, located on said hand hold, a series of terminals carried by said switch, fixed contacts, a regulator comprising substantially as described, whereby the motor is adapted to be variably energized or reversed at will, and a spring for normally throwing the switch into position to short-circuit the current, substantially as specified.

447,315. Incandescent Lamp Socket; Harry J. Gutman, of Des Moines, Ia. Application filed Sept. 29, 1890. This invention, in conjunction with an incandescent lamp, consists in an interior connecting portion, to which the main leads are secured, an outer jacket-piece surrounding the interior portion, which latter is chambered at its lower end portion to receive the upper cylindrical portion of the lamp, the entering leads being electrically connected with plate pieces on the interior of the chambered

No. 446,871.—BINDING POST.

portion. The upper portion of the lamp has vertical moving plugs being electrically connected with the filaments of the lamp. Fixed to one of said pins or plugs is a thumb piece within an angular slot in the casing of the lamp. (See illustration.)

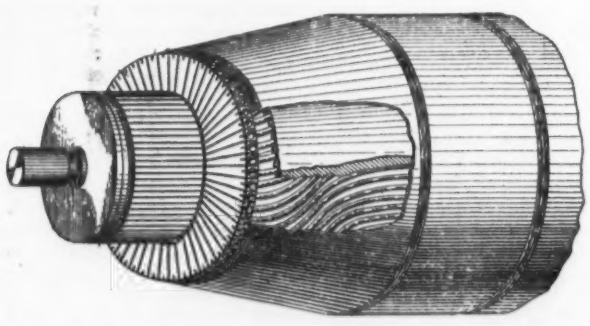
447,332. Electric Railway; Walter H. Knight, of New York. Application filed March 13, 1886. An electric car having a supplementary frame journaled on the axles supporting said car through intermediate springs and carrying an electric motor geared to the wheels.

447,338. Conduit for Underground Trolley Wires; Horace James Medbery, of Ballston, N. Y. Application filed Nov. 21, 1890. A conduit made, essentially, of fibre pulp and of substantially tubular form, the meeting edges, however, of which are not coincident either in circumferential or radial lines.

447,350. Electrical Subway; John C. Reilly, of Brooklyn, N. Y. Application filed May 20, 1890. In an electrical subway, the combination of a duct or passage consisting of a metal pipe for the reception of insulated conductors, a second duct or passage, consisting of a metal pipe fixed to the interior surface of the first named duct, a longitudinal slot in the lower side of the second duct, a plate or link traveling in said slot, to which a cable or conductor may be attached, and a suitable device located in the second duct for drawing said plate or link along in the slot and introducing the conductor in the first named duct.

447,352. Commutator-Brush; Edwin Wilbur Rice, Jr., of Lynn, Mass., Assignor to the Thomson-Houston Electric Company, of Connecticut. Application filed Nov. 28, 1890. This invention consists of a carbon commutator-brush having a metal coating gradually decreasing in thickness toward the wearing surface of the brush.

447,353. Electric Heater; Charles Clayton Rich, of Mount Vernon, N. Y. Application filed Sept. 15, 1890. An electric heater consisting of a heat-absorbing core, a series of radiating



No. 447,384.—DYNAMO ELECTRIC MOTOR OR GENERATOR.

rings encircling said core, said rings being provided on both sides with insulating washers, and insulated coils surrounding said core between the rings and washers.

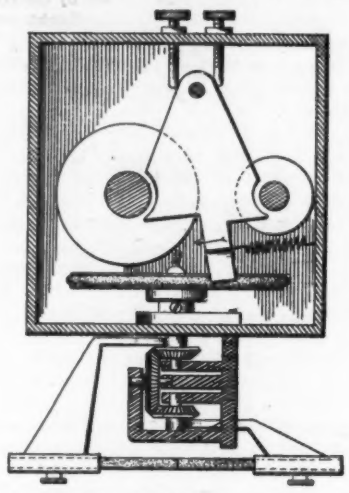
447,383. Electric Arc Lamp. Elihu Thomson, of New Britain, Conn., Assignor to the Thomson-Houston Electric Company, of Connecticut. Application filed Feb. 16, 1884. An electric arc lamp having the upper carbon rod or carrier guided in a bushing at the bottom of the lamp-frame, a cross-bar, carrying guide pieces supported by said bar below the carbon-clamp, and guided upon the side rods that support the lower carbon, a lifting and feeding clamp supported immediately above the bushing at the lower part of the lamp-frame, a lever sustained by said clamp and carrying the armatures for the lamp-magnets, a vertical arm or extension from the feed-clamp, a releasing elbow-lever arranged to engage said vertical extension, and a stop for the horizontal arm of said lever. (See illustration.)

447,384. Dynamo-Electric Motor or Generator; Elihu Thomson, of Swampscott, Mass. Application filed Oct. 20, 1890. An armature for a dynamo-electric motor or generator, having the wires leading from the armature to the commutator-segments bound together, and to the armature by an intermediate filling. (See illustration.)

447,409. Electric Time-Lock; Joseph H. Kaiser and Andrew B. Ledwith, of Brownsville, Pa. Application filed May 15, 1890. In a time-lock for safe doors, the combination consisting of a locking crank, a divided bar, actuated by a spring and connected to a crank of a secondary movement, and a means for releasing the said movement at a given time.

447,426. Telephone Switch System; Claude C. Gould, of Batavia, Assignor to the Eastern Electrical Manufacturing Company, of Wheatfield, N. Y. Application filed Oct. 10, 1887. The combination with an annunciator and its apron, of locking bolt actuated by the falling of the apron, and a movable switchbar engaging with said locking bolt and adapted to replace the fallen apron when disengaged from said locking bolt.

447,469. Commutator Brush; William Main, of Brooklyn, N. Y. Application filed Dec. 23, 1889. A commutator brush consisting of a series of contact plates so arranged as to be held in contact with the commutator preferably by centrifugal force



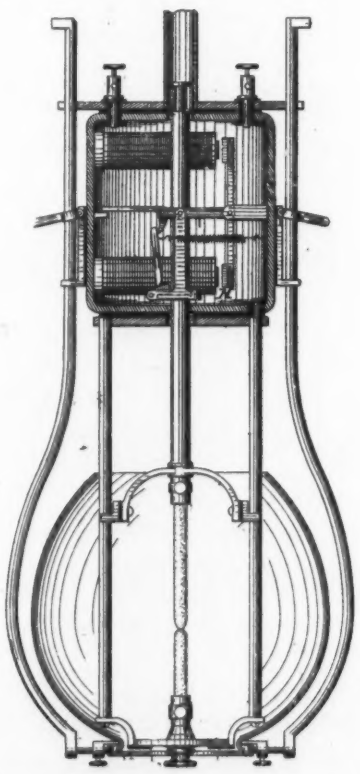
No. 447,746.—ELECTRIC ARC LAMP.

when used with a stationary commutator and rotating brush carrier, or by a spring when the brush carrier is at rest, or moving slowly.

447,482. Electric Lighting System; Barton B. Ward, of New York, Assignor to the Electric Construction and Supply Company, of same place. Application filed May 5, 1890. An electric lighting system, having main wires or leads, multiple arc branches containing translating devices, a resistance regulator for each pair of branches between one of the leads and the translating devices, said regulator comprising a coil in each branch, a resistance, part of which is in one branch and part of which is in a second branch, and a contact connected with one of the line wires bearing on said resistance and moved by the coils to throw resistance from one branch to the other.

447,485. Telephone Exchange Apparatus; Franklin G. Beach, of Chicago, Ill., Assignor to the American Bell Telephone Company, of Boston, Mass. Application filed Feb. 4, 1888. The combination, with two telephone exchange stations of two lines, each passing through each of said stations, and each to ground at one end of said stations, said lines extending to the central office, and being there connected with different portions of the same spring-jack, one of said portions of the spring-jack being connected through an annunciator to ground, and the other portion being normally insulated, and switching apparatus and generators at the different stations, whereby either subscriber may send current through said annunciator at the central office.

447,486. Universal Joint for Incandescent Lamp Brackets; Edwin C. Bennett and Elisha C. Freeze, Chicago, Ill. Application filed April 4, 1890. A ball-and-socket joint provided with an opening for a pair of flexible conducting wires having insulating material at the portion thereof which comes against the wires, the socket of said joint being formed of a cup and cap, said cap being adapted to be screwed over the cup to form an adjustable frictional clamp between the ball and



No. 447,383.—ELECTRIC ARC LAMP.

the socket, and a reversible frictional ring, open on one side, placed in a cup and serving as a bearer or seat for the ball when in position.

447,494. Rheostat; Jeremiah O'Meara, of New York, N. Y. Application filed Nov. 15, 1890. The invention consists in a coil of wire of good conductivity, mounted upon a suitable support and provided with a plug for electrical connection with an electric lamp-socket, for example, and adapted to receive electrodes or leading-out wires, whereby to utilize the current.

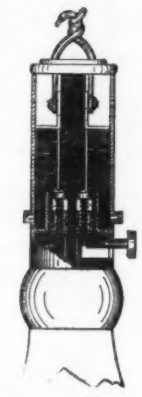
447,495. Turn-Out and Crossing for Line Conductors; Sidney H. Short, of Cleveland, O., Assignor to the Short Electric Railway Company, of same place. Application filed April 12, 1890. A two-wire system of line conductors for electric railroads, having two trunk or main line trolley-wires, one of which crosses a main wire and both affording continuous electric trolley contact.

447,529. Electromagnetic Cut-Out; Giles Taintor, of Worcester, Mass. Application filed Aug. 16, 1890. In combination with the other operating parts of an electric system of telegraph, telephone, or similar conductors, contacts connected with the several conductors, a contact block common to several of said contacts and connected to earth, and electrically operated means for making and breaking connection between said contacts and said contact-block.

447,558. Electrical Annunciator; William E. Cram, of Cambridge, Mass., Assignor of one-half to Edwin S. Beckford, of Quincy, Mass. Application filed May 23, 1890. An annunciator comprising in its construction a plurality of electromagnets extending horizontally and longitudinally toward the sides of their base board, pivoted armatures at the ends of the said electromagnets having their axes perpendicular to the cores of said electromagnets, gravity drops arranged in a plane parallel to the cores of said magnets, and provided with extensions to engage the upper ends of the armatures when the latter are in their normal position, slide rods for guiding the drops in their movements and a lifting rod for said drops.

447,569. Electrical Transformer; Rankin Kennedy, of Glasgow, Scotland, Assignor of one-half to Robert Dick, of same place. Application filed Dec. 29, 1886. A cable for transformers of electric energy, having insulated copper conductors for the primary and secondary circuits inclosed throughout their length within an outer sheathing of iron wires or plates. (See illustration.)

447,632. Trolley for Electric Railways; William J. Cavert, of Albany, and William P. Wiswall, of West Troy, N. Y. Application filed Aug. 27, 1890. A trolley for electric railways, having an arm or bearing below the wheel, and a fork projecting



No. 447,315.—INCANDESCENT LAMP SOCKET.

therefrom upward to embrace the conductor at a point beyond where it is engaged by the wheel, said fork being adapted to contact with the conductor when the trolley-wheel fails to follow it.

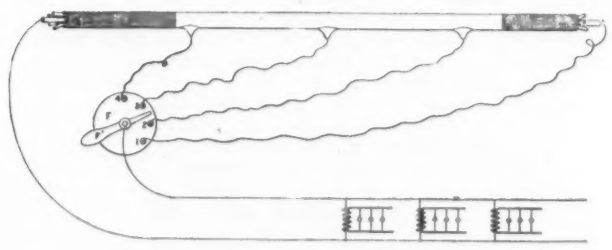
447,676. Electric Cut-Out; George C. Gammon, of Pawtucket, R. I. Application filed July 2, 1889. A cut-out, consisting of a fan, a train of gear-wheels connected therewith, a movable piece having a pawl actuating said gear-train, said movable piece being provided with an insulating stop and spring-contact adapted to slide upon said movable piece, an electromagnet, and an armature for said electromagnet, connected with the movable piece.

447,702. Electrode for Electric Arc Lamps; Albert C. Seibold, of Mount Vernon, N. Y. Application filed Oct. 30, 1890. In an arc lamp, a negative electrode consisting of a metallic bar or rod having a layer of carbon, upon one end inclosed or covered by a thin metallic plating.

447,704. Electric Motor; Robert W. Traylor, of Richmond, Va., Assignor to the Traylor Electric Company, of same place. Application filed May 21, 1890. An electric motor having yokes and parallel projections supporting the pole-pieces, and cores having a triangular arrangement between the said projections and the yokes, and united thereto by bolts and nuts, whereby an extended base of support and attachment is afforded between said parts.

447,728. Electric Snap Switch; Gerald W. Hart, of Kansas City, Mo., Assignor of one half to George S. Hegeman, of same place. Application filed Aug. 21, 1890. The combination of a cam-plate, having cams and let-offs or inclines with slotted switch-plate, a spring-plate, a spring and stud, carried by said spring-plate and engaging said switch-plate and cams.

447,734. Electric Motor; Emil B. Meyrowitz, of Ridgefield, N. J., and Ferdinand Buchop, of New York, said Buchop assignor to said Meyrowitz. Application filed May 24, 1890. A spherical



No. 447,569.—ELECTRICAL TRANSFORMER.

electric motor, comprising an equatorial frame plate with the binding posts attached to its periphery, field magnets supported by said plate within its perimeter, an armature rotating between the poles of said magnets, a pair of hemispherical, or nearly hemispherical, casing parts adjoining said frame plate on its respective sides, a motion transmitting spindle which protrudes from within the casing, and suitable electrical connections and accessories.

447,746. Electric Arc Lamp; Luther H. Buchanan, of Pasadena, Assignor of one-half to J. de Barth Shorb, of San Francisco, Cal. Application filed July 8, 1890. In an arc lamp, the combination, with two sector-shaped carbons, of supporting and carrying arms therefor, one of said arms being pivoted to a support, the centre of the pivot and the inner ends of the radii of both sectors being in alignment. (See illustration.)

447,748. Electrical Door-Bell Pull; Lewis W. Cleveland, of Portland, Me., Assignor of three-fourths to Clarence L. Marston, Lewis A. Barker and Dennis A. Meaher, all of same place. Application filed Dec. 1, 1890. An electrical door-bell pull, having a handle with a spring about its spindle, whereby it is normally held in place, with a second spring actuated spindle and the insulating material through which said spindle is movable, and the binding posts in said material, whereby when the handle and its spindle are drawn out said second spindle is insulated by its spring action and makes connection between said binding posts.

Copies of the specifications and drawings complete of any patent mentioned in this record—or of any other patent issued since 1836 *—can be had for* 25 *cents. Give date and number of patent desired, and address The W. J. Johnston Co., Ltd., Times Building, N. Y.*